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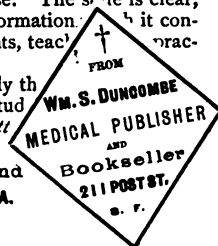
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PREFACE.

In the preparation of this Compend, no originality is claimed for its contents. Hoping only that, by its arrangement and brevity, it may to some extent fulfill the object for which it was intended—a helping hand to the student.

PHILADELPHIA, *November, 1883.*

54765



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COMPEND OF INORGANIC CHEMISTRY.

INTRODUCTION

Chemistry is that science which investigates the laws governing the movements of the atoms and molecules of which all things, animate and inanimate, are composed; and has been divided into *organic* and *inorganic*. The first named dealing with the carbon compounds that are or have been impressed with life force. The second confines itself to inanimate existence.

All substances may be divided chemically into compound and simple. A compound body can be separated and its constituents shown; a simple one cannot. Elementary or simple bodies are 68 in number, and differ widely in their normal physical condition; thus, some are gases, one is a liquid, but the greater number are solids.

TABLE OF ELEMENTS.

The following abbreviated table, taken from an excellent one by Prof. G. G. Groff* enables the student at a glance to ascertain the more prominent characteristics of the various elements; their symbols, combining weights, atomicity, specific gravity, discoverer, derivation of name, electrical condition, and when a metal, its fusing point.

L =, in the table, signifies the weight of a liter of the element, if gaseous, in grains.

*"The Chemical Elements," arranged by Prof. G. G. Groff, A.M., M.D., Professor in the University at Lewisburg, Penna.

NAME.	SYMBOL.	QUANTIVALENCE OR ATOMICITY.	SPECIFIC GRAVITY.	ATOMIC WEIGHT.	Electrical State.
1 Aluminum.	Al.	IV, (Al) ₂ ^{VI}	2.5	27.5	+
2 Antimony (Stibium).	Sb.	III, V.	6.7	122	—
3 Arsenic.	As.	III, V.	{ 5.8 gas 150	{ 75 (L=13.44)†	—
4 Barium.	Ba.	II.	4	137	+
5 Bismuth.	Bi.	III, V.	9.8	210	+
6 Boron.	B.	III.	2.63	11	—
7 Bromine.	Br.	I, III, V, VII.	{ 3.2 gas 80	{ 80 L=7.17	—
8 Cadmium.	Cd.	II.	{ 8.6 gas 56	112	+
9 Cæsium.	Cs.	I.		133	+
10 Calcium.	Ca.	II.	1.57	40	+
11 Carbon.	C.	II, IV.	{ D. 3.3 G. 2.3	12	—
12 Cerium.	Ce.	II, IV.	6.62	141.2	+
13 Chlorine.	Cl.	I, III, V, VII.	35 5	35.5	—
14 Chromium.	Cr.	II, IV, (Cr ₂) ^{VI}	6.8	52.5	—
15 Cobalt.	Co.	II, IV, (CO ₂) ^{VI}	8.9	59	+
16 Columbium (or Niobium).	Cb.	V.		94	—
17 Copper.	Cu.	II, (Cu) ₂ ^{II}	8.9	63.4	+
18 Davyium.	Da.	IV.	9.39	154	+
19 Didymium.	D.	II.	6.4	147	+
20 Erbium.	E.	II.		170.5	+
21 Fluorine.	F.	I.	19	19	—
22 Gallium.	G.	III.	6	70	
23 Gold (Aurum).	Au.	III.	19.3	196	+

DISCOVERY.	DERIVATION.	Physical State.	Fusing Point.
Wohler, 1828.	Latin <i>Alumen</i> , Alum.	metal.	425°C(?).
B. Valentine, 1460 (?).	Arabic, <i>al-ithmidum</i> .	metal.	450° (?).
Schroeder, 1694.	Greek <i>arsenicon</i> , powerful.	metal (?).	
{ Davy, 1808 (with galvanic electricity).	Greek, <i>barus</i> , heavy.	metal.	
Agricola, 1529.	German, <i>wisemat</i> .	metal.	264°
{ Davy, 1807 (with galvanic electricity).	Arabic, <i>buraq</i> .	non-metal.	
Balard, 1826.	Greek, <i>bromos</i> , stench.	liquid (non-metal)	
Stromeyer, 1817.	Greek, <i>calamine</i> , zinc.	metal.	315°
{ Bunsen, 1860 (by spectrum analysis).	Latin, <i>casius</i> , sky-blue.	metal.	
{ Davy, 1808 (galvanic electricity).	Latin, <i>calx</i> , lime.	metal.	
Ancients.	Latin, <i>carbo</i> , charcoal.	non-metal.	Infus.
{ Berzelius, 1803.	The planet <i>Ceres</i> .	metal.	
{ Hisinger, 1803.			
Scheele, 1774.	Greek, <i>chloros</i> , green.	gas.	
Vanquelin, 1797.	Greek, <i>chroma</i> , color.	metal.	3000° +
Brandt, 1733.	German, <i>Kobald</i> , bad spirit.	metal.	1670°
Hatchet, 1801.	Columbia, <i>America</i> .	metal.	
Ancients.	Latin, <i>Cyprium</i> , <i>Cyprus</i> .	metal.	1200°
Geo. Kem, 1877.	Sir. H. Davy.	metal.	
Mosander, 1841.	Greek, <i>didumos</i> , twins.	metal.	
Mosander, 1843.	Swedish town, Ytterby.	metal.	
{ Not yet isolated.	Latin, <i>fluo</i> , to flow.	non-metal.	
{ Knox, 1836.			
Boisbaudran, 1877.	<i>Gaul</i> , France.	metal.	30.1°
Ancients.	Anglo-Saxon, <i>gol</i> .	metal.	1250°

NAME.	SYMBOL.	QUANTIVALENCE OR ATOMICITY.	SPECIFIC GRAVITY.	ATOMIC WEIGHT.	Electrical State.
24 Glucinum (Beryllum).	Gl.	II.	2.15	14	+
25 Hydrogen (or Hydrogenium).	H.	I.	1	(L=.0896gm)	+
26 Indium.	In.	II.	7.4	113.4	+
27 Iodine.	I.	I.	{ gas 127 4.9	{ (L=1038) 127	—
28 Iron (Ferrum).	Fe.	II, IV, (Fe ₂) ^{VI}	7.8	56	+
29 Iridium.	Ir.	II, IV, VI.	21.1	198	+
30 Lead (Plum- bum).	Pb.	II, IV.	11.3	207	+
31 Lanthanium.	La.	II.	6.1	139	+
32 Lithium.	Li.	I.	.6	7	+
33 Magnesium.	Mg.	II.	1.7	24	+
34 Manganeseum.	Mn.	II, IV, (Mn ₂) ^{VI}	8	55	+
35 Mercury. (Hydrargum).	Hg.	(Hg ₂) ^{II} II.	{ 13.6 gas 100	{ 200 (L=8.96)	+
36 Molybdenum.	Mo.	II, IV, VI.	8.6	96	—
37 Nickel.	Ni.	II, IV, (Ni ₂) ^{VI}	8.8	59	+
38 Nitrogen.	N.	I, III, V.	14	14	—
39 Osmium.	Os.	II, IV, VI.	21.4	199	+
40 Oxygen.	O.	II.	16	{ 16 (5.55=L)	—
41 Phosphorus.	P.	III, V.	{ 2.2 1.83 gas 62	31	—
42 Platinum.	Pt.	II, IV.	21.5	197.4	+
43 Potassium (Kalium).	K.	I, III, V.	{ .86 gas 39.1	{ 39.1 (L=3.5)	+
44 Palladium.	Pd.	II, IV.	11.6	106.5	+
45 Rhodium.	Ro.	II, IV, VI.	11	104.4	+
46 Rubidium.	Rb.	I.		85.74	+

DISCOVERY.	DERIVATION.	Physical State.	Fusing Point.
Wohler, 1798.	Greek, <i>glukus</i> , sweet.	metal.	
Cavendish, 1766.	Greek, <i>hudos</i> and <i>gen-nao</i> , water-former.	gas (<i>metal</i>).	—600°
{ Reich & Richter, 1863. (spectrum analysis).	Indigo blue.	metal.	
Courtois, 1811.	Greek, <i>ion</i> , violet.	non-metal.	107°
Ancients.	Anglo-Saxon, <i>iron</i> .	metal.	2000° +
Tennant, 1803.	Latin, <i>iris</i> , rainbow.	metal.	3000° +
Ancients.	Anglo-Saxon, <i>lead</i> .	metal.	325°
Mosander, 1841.	Greek, <i>lanthano</i> , to conceal.	metal.	
{ Davy, 1818. Arvedson, 1818.	Greek, <i>lithos</i> , a stone.	metal.	180°
{ Bussy, 1830. Davy, 1808.	City of Magnesia, Asia.	metal.	red heat.
Galm, 1774.	City of Magnesia, Asia.	metal.	3000° +
Ancients.	Name of planet.	liquid, <i>metal</i> .	—40°
Hjelm, 1782.	Greek, <i>molybdos</i> , lead.	metal (?).	
Cronstedt, 1751.	German, <i>kupfer-nickel</i> .	metal.	3000° +
Rutherford, 1772.	Greek, <i>nitre-forming</i> .	gas.	—400°
Tennant, 1803.	Greek, <i>osme</i> , odor.	metal.	high.
Priestley, August 1, 1774.	Greek, <i>acid-forming</i> .	gas.	—600°
Brandt (in urine), 1669.	Greek, <i>light-bearing</i> .	non-metal.	44°
Wood, 1741.	Spanish, <i>platina</i> .	metal.	3000° +
Davy, 1807.	English, " <i>pot-ashes</i> ."	metal.	62.5°
Wollaston, 1803.	Name of planet.	metal.	high.
Wollaston, 1803.	Greek, <i>rhodon</i> , a rose.	metal.	high.
Bunsen, 1860.	Latin, <i>rubidus</i> , dark red.	metal.	223° (?)

NAME.	SYMBOL.	QUANTIVALENCE OR ATOMICITY.	SPECIFIC GRAVITY.	ATOMIC WEIGHT.	Electrical State.
47 Ruthenium.	Ru.	II, IV, VI.	11.4	104.4	+
48 Selenium.	Se.	II, IV, VI.	4.8	79.5	—
49 Silicon.	Si.	II, IV.	2.6	28	—
50 Silver (Argentum).	Ag.	I, III.	10.5	108	+
51 Sodium (Natrium).	Na.	I, III.	$\left\{ \begin{array}{l} .97 \\ \text{gas } 23 \end{array} \right.$	$\left\{ \begin{array}{l} 23 \\ (L=2.06) \end{array} \right.$	+
52 Strontium.	Sr.	II, IV.	2.54	87.5	+
53 Sulphur.	S	II, IV, VI.	$\left\{ \begin{array}{l} 2 \\ \text{gas } 32 \end{array} \right.$	$\left\{ \begin{array}{l} 32 \\ (L=2.86) \end{array} \right.$	—
54 Tantalum.	Ta.	V	10.78	182	—
55 Tellurium.	Te.	II, IV, VI.	6.6	128	—
56 Thallium.	Tl.	I, III.	11.8	204	+
57 Terbium.	Ter.		7.9	148.5	
58 Thorium.	Th.	II, IV.	7.9	231	+
59 Tin (Stannum).	Sn.	II, IV.	7.3	118	+
60 Titanium.	Ti.	II, IV.		50	—
61 Tungsten.	W.	IV, VI.	17.6	184	—
62 Uranium.	Ur.	II, IV, (Ur ₂) ^{VI}	18.4	240	+
63 Vanadium.	V.	III, V, (V ₂) ^{VI} (V ₂) ^{VIII}		51.3	—
64 Yttrium.	Yt.	II.	4.8	61.6	+
65 Zinc.	Zn.	II.	$\left\{ \begin{array}{l} 7 \\ \text{gas } 32.5 \end{array} \right.$	65	+
66 Zirconium.	Zr.	II, IV.	4.1	89.6	+
67 Muriu.	M.				

DISCOVERY.	DERIVATION.	Physical State.	Fusing Point.
Claus, 1845.	Ruthenia, <i>Russia</i> .	non-metal.	high.
Berzelius, 1817.	Greek, <i>selenē</i> , the moon.	non-metal.	{ 100° 217°
Berzelius, 1823.	Latin, <i>silex</i> , flint.	non-metal.	
Ancients.	Anglo-Saxon, <i>Silfor</i> .	metal.	1000°
Davy, 1807	} By aid of galvanic current.	Latin, <i>salsola</i> , soda.	metal.
Davy, 1807		<i>Strontian</i> , Scotland.	metal.
Ancients.	Latin, <i>Sulfur</i> .	non-metal.	red heat.
Ekeberg, 1802.	The god <i>Tan'alus</i> .	metal.	115°
Klaproth, 1798.	Greek, <i>tellus</i> , earth.	non-metal.	500°
{ Crookes, 1861 (by spec-	} trum analysis).	Greek, <i>thallus</i> , bud-	metal.
		ding twig.	
Mosander, 1843.	Greek, <i>ter</i> , the third.	metal (?)	294°
Berzelius, 1829.	The Swedish god, <i>Thor</i> .	metal.	
Ancients.	Anglo-Saxon, <i>tin</i> .	metal.	230°
Klaproth, 1791.	The Myth, <i>Titans</i> .	metal (?)	
De Luyart.	Swedish, <i>heavy stone</i> .	metal.	high.
{ Klaproth, 1798.	} Name of planet, <i>Uranium</i>	metal.	
{ Peligot, 1841.			
Lefstrom, 1830.	The Swede god, <i>Vanadis</i> .	metal.	high.
Wohler, 1828.	<i>Ytterby</i> , Sweden.	metal.	
Paracelsus, 16th Century.	German, <i>Zinc</i> .	metal.	412°
Berzelius, 1824.	Zeylonese, <i>zircon</i> .	metal (?)	
1880, by spectrum analysis.	Muria, salt water.		

CHEMICAL NOMENCLATURE is the naming of bodies from some chemical or physical property possessed by them, if elementary. If compound, then from their composition.

Matter, whether elementary or compound, is composed of *atoms* arranged in *molecular* form.

Atoms are the smallest particles of matter that can exist, and *when similar* are called *homogeneous*, *when dissimilar*, *heterogeneous*.

A molecule is composed of *two or more atoms*, which may be *like or unlike*; if the first, it is called *simple*, when the second, *compound*.

The *bond of union* between *like atoms* is *cohesion*; *unlike, chemical affinity*; these bonds are greatly affected by the imponderable forces; thus, heat and light will modify and sometimes destroy them.

Atoms possess the power of combination and displacement, obedient to their own inherent power of selection. This property is called their *quantivalence*, or range of combination, and on it is based the grouping of Monads, Diads, Triads, etc.; the elements being styled Monatomic, Diatomic, Triatomic, etc.

The quantivalence of an element is expressed by Roman numerals, placed at the upper right-hand corner of the symbol, as, H^I , O^{II} , N^{III} , Cr^{IV} .

A *Chemical Symbol* is the first letter of the name of an element or when, as in many instances, there are several elements whose names begin with the same letter, then a distinguishing letter is added; these, by universal consent, among chemists, represent the elements. As, C, signifies carbon; Ca, calcium; Co, cobalt; Cr, chromium; Cl, chlorine; Cd, cadmium, and Ce, Cerium. If it is desired to express a compound, the symbols are used that represent the elements entering into its composition. Should more than one combining weight of any element be present, then the additional quantity is expressed by figures placed at the lower right-hand corner of the symbol.

A *Monad* has a single range, or one arm of affinity, and is expressed thus \bigcirc —.

A *Diad* has a double range, or two arms, and is represented thus — \bigcirc — or \bigcirc ==.

A *Triad* has a triple range, three arms, and is shown thus \bigcirc —

A *Tetrad* has a quadruple range, four arms, and is displayed thus — \bigcirc —.

There are also Pentads and Hexads, having the respective ranges of five and six, expressed by the corresponding number of arms.

LAWS OF MIXTURE.

- 1st. Some bodies mingle in all proportions, as alcohol and water.
- 2d. Some bodies mingle in all proportions up to a limit, called the point of saturation. As common salt and water.

LAWS OF COMBINATION.

- 1st. Bodies combine in fixed and definite proportions. That is, the same compound, if pure, wherever found, contains the same elements and in the same quantity; as every two hundred and thirty-five and five-tenths grains of calomel contains two hundred of mercury and thirty-five and five-tenths grains of the gas chlorine; every eighteen grains of water contains sixteen of the gas oxygen and two of hydrogen.

- 2d. Combining weights.

They are the quantities by weight in which one body combines with another. As sixteen (16) grains of oxygen will combine with two hundred (200) grains of mercury, or sixty-four grains of copper, etc. The combining weight of a compound is the sum of those of its constituents.

- 3d. Multiple and submultiple proportions.

When a body combines with another in more than one quantity, the second, third, fourth and fifth are multiples of the first. But should they combine in the proportions of one to one and a half, or two to three, then it is a submultiple.

- 4th. Gases combine by *Bulk* or *Volume*.

That is, a given volume or bulk of a gas will combine with an equal given volume or bulk of another. Thus, one cubic inch of hydrogen will combine with one cubic inch of chlorine and form two cubic inches of gaseous hydrochloric acid. Some gases have the power of combining in more than one proportion by bulk with another. As two bulks of nitrogen will combine with one, two, three, four and five bulks of oxygen, forming five different compounds.

Non-metallic elements or electro-negatives combine with positives or metals, to form compounds that terminate in *ide*, as oxide, chloride, iodide, bromide, fluoride, sulphide, and phosphide. The prefixes mon, di, tri, tetra, pent, and sesqui, are used to denote the quantity of the non-metallic element in combination. Per and hypo are also used; per signifying the highest, hypo, under.

When *acids* are formed by the union of elements, the one having the largest quantity of the non-metallic body terminates in *ic*, the lower in *ous*; they are usually oxygen compounds.

Acids, with few exceptions, are only active in their power of combination

when united with hydrogen; when terminating in ic, form compounds ending in ate; if terminating in ous, the compounds result.

Gravity means weight; specific gravity is the relative weight of equal bulks. To obtain the specific gravity of a body heavier than water, we first weigh it in air, then in water; the difference is the weight of the bulk of water displaced; the weight in air is divided by that of the bulk of water, and the quotient is the specific gravity.

EXAMPLE.

A piece of lead weighs in air.....	107.0 grs.
Immersed in water.....	97.4 grs.

The difference, or weight of bulk of water displaced..... 9.6 grs.

$$107.0 \div 9.6 = 11.$$

For bodies lighter than water, weigh in the air, then attach a heavy substance, sufficiently so to sink the two; weigh again in the air, immerse in water and weigh; the difference is the weight of the bulk of water equal of that of the light and heavy substance. Detach the heavy body, weigh in air, then in water; the difference here is the weight of the bulk of water equal to the heavy body alone; this, when subtracted from the weight of bulk of water equal to the two bodies, gives that of the light body alone. We now divide the weight in the air by the weight of the bulk of water, and the quotient is the specific gravity.

EXAMPLE.

Light substance, a piece of cork, weighs in air.....	2.3 grs.
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Attached to a piece of lead, the whole weighs.....	109.3 grs.
Immersed in water, they now weigh.....	87.2 grs.

Weight of bulk of water equal to lead and cork.....	22.1 grs.
Weight of lead in air.....	107.0 grs.
Weight of lead in water.....	97.4 grs.

Weight of equal bulk of water.....	9.6 grs.
Weight of bulk of water equal to lead and cork.....	22.1 grs.
Weight of bulk of water equal to lead alone.....	9.6 grs.

Weight of bulk of water equal to cork alone.....	12.5 grs.
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$$2.3 \div 12.5 = .184.$$

It is often necessary to obtain the specific gravity of bodies soluble in water; some other liquid is then taken, the most common being alcohol, or oil of turpentine. Whichever is used, its specific gravity must be accurately known. We now weigh in the air, then in the proper liquid; subtraction gives the weight of an equal bulk of that fluid; this, when multi-

plied by one hundred, and divided by the specific gravity of liquid used, gives us the weight of the bulk of water equal to the body; all that is now necessary is to divide the weight in air by that of the bulk of water, and the specific gravity is obtained.

EXAMPLE.

Weight of sugar in air..... 400.0 grs.

Weight of sugar in oil of turpentine..... 182.5 grs.

Weight of equal bulk of oil of turpentine..... 217.5 grs.

$217.5 \times 100 \div 87 = 250$ or weight of an equal bulk of water.

$400 \div 250 = 1.6$ the specific gravity. —FOWNES.

The specific gravity of liquids is obtained by dividing the weight of a given bulk by that of the same of water. Or by means of an instrument called the Hydrometer.

Specific gravity of gases is obtained by weighing as for liquids.

OXYGEN.

Symbol O. Combining weight 16. Volume 1 \square .

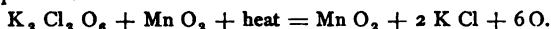
Specific gravity 1.1057. One liter weighs 1.430 grm. 100 cubic inches weighs 34 grains.

Discovered by *Priestley* in 1774, also by *Scheele* in the following year.

Preparation. Obtained from water ($H_2 O$) by decomposing it by galvanic electricity. From the following substances by heat: Mercuric oxide ($Hg O$); Manganese dioxide ($Mn O_2$); Tri-plumbic tetroxide ($Pb_3 O_4$); Potassium nitrate ($K_2 N_2 O_6$) or ($K N O_3$); Potassium chlorate ($K_2 Cl_2 O_6$) or ($K Cl O_3$); also from Potassium acid chromate.

$K_2 H_2 2Cr O_4$ with hydric sulphate ($H_2 SO_4$).

The method of Tessié du Mottay is by heating a mixture of manganese dioxide ($Mn O_2$) with caustic soda ($Na_2 O$); Manganate of sodium is formed ($Na_2 Mn O_4$) which is decomposed by steam, causing the decomposition of the manganate, and oxygen is liberated. This gas is generally prepared by heating a mixture of four parts by weight of potassium chlorate ($K_2 Cl_2 O_6$) or ($K Cl O_3$) with one of manganese dioxide ($Mn O_2$) which plays no part other than a conductor of heat, as it does not undergo decomposition.



Properties. It is without color, odor, or taste, a supporter of combustion and stimulant. In its nascent state it is a bleacher. This gas is electro-negative, a diad, and forms one-fifth of the atmosphere, eight-ninths of the water and one-half of the earth.

Liquefiable at a great pressure at a low temperature.

Test. A solution of the pyrogallate of potassium will absorb oxygen and become black.

Ozone. *Allotropic or Active Oxygen.*

Discovered by *Schönbein* in 1840. It may be obtained by the slow combustion of phosphorus in moist oxygen, or by passing electricity through the dry gas.

Properties. It has a peculiar smell, oppressive in character; oxidizes metals, sets free iodine, chlorine, etc. Heat converts it into the passive gas.

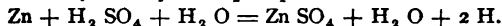
HYDROGEN.

Symbol H. Combining weight 1. Volume 1 □.

Specific gravity .08961. 100 cubic inches weighs 2.14 grains. 1 liter weighs .08961 grm.

Discovered by *Cavendish* in the year 1766.

Preparation. Obtained by decomposing *water* (H_2O) by galvanic electricity. By the decomposition of *steam* with hot iron. From *water* (H_2O) by the action of the *alkaline metals*, potassium (K) or sodium (Na). Acting upon the *metals zinc* (Zn) or iron (Fe) with hydric chloride (HCl) or dilute hydric sulphate H_2SO_4 .



Properties. A gas without taste, odor, or color, not poisonous, burns with a colorless flame, producing great heat and forming water H_2O ; it is the *lightest* of all known bodies, *electropositive* and a *monad*.

Tests. Its inflammability and absorption by bromine.

OXYGEN COMPOUNDS.

Hydrogen monoxide, water H_2O .

Made by uniting 2 vols. of *hydrogen* (H) with 1 vol. of *oxygen* (O).

Hydrogen dioxide (H_2O_2).

Discovered by *Thenard* in the year 1818.

Obtained by acting on barium dioxide (BaO_2), powdered and moistened with water (H_2O), with hydric chloride (HCl).



Properties. When pure it is a dense liquid, without color or odor, very unstable, and having a specific gravity of 1.45.

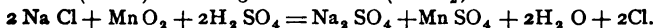
CHLORINE.

Symbol Cl. Combining weight 35.5. Volume 1 □.

Specific gravity 2.45. One liter weighs 3.208 grains. 100 cubic inches weighs 78 grains.

Discovered by *Scheele* in the year 1774, and proven to be an element by *Davy*, in 1810.

Preparation. By the action of *Hydric Sulphate* ($\text{H}_2 \text{SO}_4$) on *Sodium Chloride* (Na Cl) and *Manganese Dioxide* (Mn O_2).



Or by acting on *Manganese Dioxide* (Mn O_2) with *Hydric Chloride* (H Cl).



Properties. A greenish-yellow gas, irrespirable, soluble in water ($\text{H}_2 \text{O}$) disinfectant, and when in the presence of moisture ($\text{H}_2 \text{O}$) a bleacher. It is *electro-negative* and a *monad*. Can be *liquefied* at a pressure of *four atmospheres*.

Test. A soluble salt of silver (Ag), as a Nitrate ($\text{Ag}_2 \text{N}_2 \text{O}_6$), gives a white precipitate.

Hydrogen Chloride, Hydrochloric or Muriatic Acid (H Cl). Specific gravity of the gas 1.26, of the liquid 1.17. One liter weighs 1.63 grm. 100 cubic inches weighs 38 grains.

Discovered by *Priestley* in the year 1772.

Obtained by the action of Hydric sulphate ($\text{H}_2 \text{SO}_4$) on Sodium Chloride (Na Cl). $2 \text{Na Cl} + \text{H}_2 \text{SO}_4 = \text{Na}_2 \text{SO}_4 + 2 \text{H Cl}$. The gas is passed into water, which absorbs it in large quantities; when the substances used are pure, and the vessels are of glass, a corresponding acid is obtained. The commercial acid is tinged yellow, due to the presence of iron (Fe).

Properties. A colorless gas, liquefiable at a pressure of forty atmospheres. Water absorbs it with avidity, taking up four hundred and eighty times its bulk.

Test. A soluble salt of silver (Ag), as the Nitrate ($\text{Ag}_2 \text{N}_2 \text{O}_6$), gives a white precipitate.

IMPORTANT OXYGEN COMPOUNDS.

Hydrogen Hypochlorite,	}	$\text{H}_2 \text{Cl}_2 \text{O}_2$.
Hypochlorous Acid,		
Hydrogen Chlorite,	}	$\text{H}_2 \text{Cl}_2 \text{O}_4$.
Chlorous Acid,		
Hydrogen Chlorate,	}	$\text{H}_2 \text{Cl}_2 \text{O}_6$.
Chloric Acid,		
Hydrogen Per chlorate,	}	$\text{H}_2 \text{Cl}_2 \text{O}_8$.
Per chloric Acid,		

Hydrogen Hypochlorite, Hypochlorous Acid, $\text{H}_2 \text{Cl}_2 \text{O}_2$. May be obtained by passing *chlorine* (Cl) into water ($\text{H}_2 \text{O}$) in which freshly

precipitated calcium carbonate (Ca CO_3) is suspended. Carbonic anhydride (CO_2) escapes as a gas, calcium chloride (Ca Cl_2) with the acid remaining in the water ($\text{H}_2 \text{O}$). Distillation will furnish the acid.

$\text{Ca CO}_3 + 4 \text{Cl} + \text{H}_2 \text{O} = \text{Co}_2 \text{Ca Cl}_2 + \text{H}_2 \text{Cl}_2 \text{O}_2$ (Williamson).

Hydrogen chlorite, Chlorous Acid $\text{H}_2 \text{Cl}_2 \text{O}_4$. Is obtained by distilling potassium chlorate ($\text{K}_2 \text{Cl}_2 \text{O}_8$) with hydrogen nitrate ($\text{H}_2 \text{N}_3 \text{O}_6$) and arsenious anhydride ($\text{As}_2 \text{O}_3$). It is a non-important greenish-yellow liquid, possessing bleaching and oxidizing properties; forming *chlorites* with the alkalis and alkaline earths.

Hydrogen chlorate, Chloric Acid, $\text{H}_2 \text{Cl}_2 \text{O}_6$. Discovered by *Gay-Lussac*, and prepared by decomposing Barium Chlorate ($\text{Ba Cl}_2 \text{O}_6$) with hydrogen sulphate ($\text{H}_2 \text{SO}_4$). $\text{Ba Cl}_2 \text{O}_6 + \text{H}_2 \text{SO}_4 = \text{Ba SO}_4 + \text{H}_2 \text{Cl}_2 \text{O}_6$. When concentrated it is a syrupy liquid, possessing strong bleaching power.

Hydrogen Perchlorate, Perchloric Acid, $\text{H}_2 \text{Cl}_2 \text{O}_8$. Discovered by *Stadion*, and obtained by distilling potassium perchlorate ($\text{K}_2 \text{Cl}_2 \text{O}_8$) with hydrogen sulphate ($\text{H}_2 \text{SO}_4$). $\text{K}_2 \text{Cl}_2 \text{O}_8 + \text{H}_2 \text{SO}_4 = \text{K}_2 \text{SO}_4 + \text{H}_2 \text{Cl}_2 \text{O}_8$. It is a colorless liquid, liable to undergo decomposition.

IODINE.

Symbol I. Combining weight 127. Volume I \square .

Specific gravity 4.948. Of the vapor 8.716. One liter weighs 11.36 grms.

Discovered by *Courtois* in the year 1812.

Iodine is found combined with Sodium (Na) in the ashes of marine plants. It is obtained by passing *chlorine* gas (Cl) through a saturated solution of these ashes, which frees the iodine and some bromine. Benzine is then added; this dissolves the *iodine*, leaving any *bromine* that may have been liberated; the benzine solution of iodine is now drawn off and treated with potassic hydrate (K H O), when *potassium iodide* (K I) and *potassium iodate* $\text{K}_2 \text{I}_2 \text{O}_6$ are formed; the last named salt is converted into the iodide by heat. 12I in solution $+ 6 (\text{K}_2 \text{O H}_2 \text{O}) = 10 \text{K I} + \text{K}_2 \text{I}_2 \text{O}_6$. *Potassium iodide* (K I) is now treated with *manganese dioxide* (Mn O_2) and hydric sulphate ($\text{H}_2 \text{SO}_4$) when potassium sulphate $\text{K}_2 \text{SO}_4$ manganese sulphate (Mn SO_4) and water ($\text{H}_2 \text{O}$) are formed; the iodine (I) passing off as a vapor, because of the heat used, and condenses in the appropriate vessels arranged for the purpose.

$2 (\text{K I}) + (\text{Mn O}_2) + 2 (\text{H}_2 \text{SO}_4) = (\text{K}_2 \text{SO}_4) + (\text{Mn SO}_4) + 2 (\text{H}_2 \text{O}) + 2 \text{I}$.

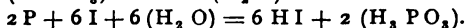
Properties. A brownish metallic-looking solid body; slightly soluble

in water (H_2O), freely so in alcohol (C_2H_6O) and alkaline solutions. It is an electro-negative and a monad.

Tests. A solution of starch is turned blue. A soluble salt of silver (Ag) gives a yellow precipitate.

Hydrogen Iodide (HI), or Hydriodic Acid.

Prepared by distilling a mixture of iodine (I), phosphorus (P), powdered glass ($CaSiO_3$) and water (H_2O).



Properties. It is without color, very acid and highly soluble in water (H_2O). Specific gravity 4.4.

OXYGEN COMPOUNDS OF IODINE.

Hydrogen Iodate, } $H_2I_2O_6$.
Iodic Acid,

Hydrogen Per Iodate, } $H_2I_2O_8$.
Per Iodic Acid,

Hydrogen Iodate, $H_2I_2O_6$, or Iodic Acid.

Made by acting on iodine (I) with hydric nitrate ($H_2N_2O_6$) and heat, evaporating to dryness, dissolving in water (H_2O) and setting aside to crystallize.

Properties. It is a solid body, without color, crystallizing in orthorhombic prisms.

Hydrogen Per Iodate, $H_2I_2O_8$, or Per Iodic Acid.

Made by passing chlorine into a mixed solution of sodium iodate ($Na_2I_2O_6$) and sodium hydrate ($Na_2O + H_2O$). The sodium periodate $Na_2I_2O_8$ is then dissolved in hydric nitrate $H_2N_2O_6$, and lead nitrate PbN_2O_6 is added; lead periodate is formed, and is decomposed by hydric sulphate H_2SO_4 , which throws down lead sulphate ($PbSO_4$) and the acid remains in solution, and is of little importance.

Nitrogen Iodine (NI_3) is made by the action of iodine (I) on strong ammonia ($NH_3 + H_2O$). It is a non-important explosive body.

CHLORIDES OF IODINE.

There are three *chlorides of iodine*. Monochloride (ICl), Trichloride (ICl_3), and Tetrachloride (ICl_4), which are of little importance.

BROMINE.

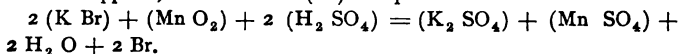
Symbol Br. Combining weight 80. Volume 1 \square .

Specific gravity 2.976. Of the vapor 5.41. One liter weighs 6.99 grms.

Discovered by Balard in the year 1826.

Preparation. After the separation of sodium chloride (NaCl) from

salt water, by evaporation, there remains a bitter liquid, which contains, among other salts, sodium bromide (Na Br). To free the bromine (Br), chlorine (Cl) is passed into this liquid; ether is then added, which dissolves the bromine (Br) and from its lightness floats on the surface of the water ($H_2 O$); it is now drawn off and potassic hydrate ($K_2 O H_2 O$) added, forming potassium bromide (K Br) and potassium bromate ($K_2 Br_2 O_6$) which are obtained by evaporation. The last named salt can be converted into the bromide (K Br), by heat. Potassium bromide (K Br) is mixed with manganese dioxide ($Mn O_2$) and hydric sulphate ($H_2 SO_4$) and heat applied, when bromine (Br) will pass off.



Properties. A volatile, blood-red liquid, of an offensive odor, sparingly soluble in water ($H_2 O$), disinfectant, escharotic, electro-negative and nomad.

Test. A soluble salt of silver (Ag), as the Nitrate $Ag_2 N_2 O_6$, gives a yellowish-white precipitate, slightly soluble in ammonia.

Hydrogen Bromide, } H Br.
Hydro-bromic Acid,

Hydrogen Bromide (H Br) or *Hydrobromic Acid*.

This substance is prepared by a process similar to Hydrogen Iodide (H I), and has properties very like that acid.

OXYGEN COMPOUND.

Hydrogen Bromate, } $H_2 Br_2 O_6$.
Bromic Acid,

Hydrogen Bromate (H Br) or *Bromic Acid*.

Can be prepared by decomposing Barium Bromate ($Ba Br_2 O_6$) with Hydric Sulphate ($H_2 SO_4$). $(Ba Br_2 O_6) + (H_2 SO_4) = (Ba SO_4 + H_2 Br_2 O_6)$.

Hydrogen Hypobromite, or Hypobromous acid, is also known, but is of little importance.

FLUORINE.

Symbol F. Combining weight 19. One liter weighs 1.7 grm.

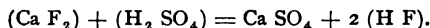
This element has never been separated, but a body supposed to be fluorine has been obtained by decomposing silver fluoride ($Ag F$) with Chlorine (Cl) or Iodine (I) in vessels made of Calcium Fluoride ($Ca F_2$).

HYDROGEN COMPOUNDS OF FLUORINE.

Hydrogen Fluoride (H F) or *Hydrofluoric Acid*. *Hydrogen Fluosilicate* ($H_2 Si F_6$) or *Hydrofluosilicic Acid*.

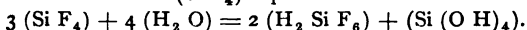
Hydrogen Fluoride (H F), or *Hydrofluoric Acid*, may be obtained by

the action of *heat* and *Hydric Sulphate* ($\text{H}_2 \text{SO}_4$) on *Calcium Fluoride* (Ca F_2), in vessels made of *Lead* or *Platinum*, connected with a cooled receiver of the same metal.



Properties. A colorless, volatile liquid, which gives off white fumes in the air, of a highly suffocating character; used in the arts for etching on glass.

Hydrogen Fluosilicate ($\text{H}_2 \text{Si F}_6$) or *Hydrofluosilicic Acid*, is formed when Silicon Tetrafluoride (Si F_4) is passed into water.



Salts of Potassium (K) are precipitated by this acid.

NITROGEN.

Symbol N. Combining weight 14. Volume 1 \square .

Specific gravity 0.972. One liter weighs 1.2565 gm. 100 cubic inches weighs 30 grains.

Discovered by *Rutherford* in the year 1772.

Preparation. This gas may be obtained in many ways, the more common being as follows: From the atmosphere ($\text{N}_4 + \text{O}$) by burning *phosphorus* (P) in a bell jar containing air over *water*. Phosphoric anhydride ($\text{P}_2 \text{O}_5$) is formed, which is absorbed by the water ($\text{H}_2 \text{O}$) and the nitrogen remains. By the action of hydric nitrate ($\text{H}_2 \text{N}_2 \text{O}_6$) on flesh. Treating *ammonia* (N H_3) with *chlorine* (Cl). $(\text{N H}_3) + 3 \text{Cl} = 3 (\text{H Cl}) + \text{N}$. From *potassium nitrite* ($\text{K}_2 \text{N}_2 \text{O}_4$) and *ammonium chloride* ($\text{N H}_4 \text{Cl}$). $(\text{K}_2 \text{N}_2 \text{O}_4) + 2 (\text{N H}_4 \text{Cl}) = 2 (\text{K Cl}) + 4 (\text{H}_2 \text{O}) + 4 (\text{N})$.

Properties. A gas without color, odor, or taste; will not burn or support combustion, and is not poisonous. It belongs to the group of pentads.

Tests. Its forming *ammonia* (N H_3), and cyanogen (C N), by the use of the proper substances.

THE ATMOSPHERE

Is a gaseous envelope that surrounds our globe, extending upward many miles, and is composed of *nitrogen* (N) and *oxygen* (O) intimately mingled in the proportion of

BY WEIGHT		BY VOLUME	
O.....	23.10	O.....	20.90
N.....	76.90	N.....	79.10
	100.00		100.00

Carbonic anhydride (C O_2), ammonia (N H_3), the vapor of water ($\text{H}_2 \text{O}$) and other substances are also found in it.

OXYGEN COMPOUNDS OF NITROGEN.

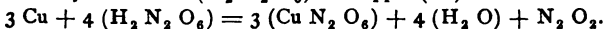
<i>Nitrogen Monoxide,</i>	}	$N_2 O.$
<i>Laughing gas,</i>		
<i>Nitrogen Dioxide,</i>	}	$N_2 O_2.$
<i>Nitrous Anhydride,</i>		
<i>Nitrogen Trioxide,</i>	}	$N_2 O_3.$
<i>Hydrogen Nitrite,</i>		
<i>Nitrous Acid,</i>	}	$H_2 N_2 O_4.$
<i>Nitrogen Tetroxide,</i>		
<i>Hypo Nitric Acid Anhydride,</i>	}	$N_2 O_4.$
<i>Nitrogen Pentoxide,</i>		
<i>Nitric Anhydride,</i>	}	$N_2 O_5.$
<i>Hydrogen Nitrate,</i>		
<i>Nitric Acid,</i>	}	$H_2 N_2 O_6$ or $H N O_3.$
<i>Aqua Fortis,</i>		

Nitrogen Monoxide, $N_2 O$, or Laughing gas.

Discovered by *Priestley* in the year 1785, and made by heating ammonium nitrate $(N H_4)_2 N_2 O_6$. $(N H_4)_2 N_2 O_6 + \text{heat} = 4 (H_2 O) + 2 (N_2 O)$. Specific gravity 1.524. One liter weighs 1.97 grm. 100 cubic inches weighs 47 grains.

Properties. A gas without color or odor, having a sweetish taste, is an anæsthetic, and supporter of combustion, liquefiable by a pressure of fifty atmospheres.

Nitrogen Dioxide ($N_2 O_2$). Discovered by *Dr. Hales*. Made by the action of Hydric Nitrate ($H_2 N_2 O_6$) on Copper (Cu).



Specific gravity 1.0365. One liter weighs 1.343 grm. 100 cubic inches weighs 32 grains.

Properties. A colorless gas, non-supporter of combustion, and irrespirable. Combines with oxygen.

Nitrous Anhydride ($N_2 O_3$) or Nitrogen Trioxide. Made by subjecting a mixture of four measures of Nitrogen Dioxide and one of Oxygen to a temperature of -18° , when a blue liquid condenses, which gives off orange-red fumes. Or by the action of Hydric Nitrate ($H_2 N_2 O_6$) on Arsenious acid ($As_2 O_3$).

Nitrogen Tetroxide ($N_2 O_4$) or Hyponitric Anhydride. When Plumbic Nitrate ($Pb N_2 O_6$) is subjected to heat, Plumbic Oxide ($Pb O$) remains, and Nitrogen Tetroxide ($N_2 O_4$) passes off. By condensation at a low temperature, transparent crystals are formed.

Nitrogen Pentoxide ($N_2 O_5$) or Nitric Anhydride. Discovered by

Deville in the year 1849, and made by acting on Argentic Nitrate ($\text{Ag}_2\text{N}_2\text{O}_6$) with Chlorine ($\text{Ag}_2\text{N}_2\text{O}_6 + 2\text{Cl} = 2(\text{AgCl}) + \text{O} + \text{N}_2\text{O}_5$).

Properties. A colorless body, crystallizing in six-sided prisms.

Hydrogen Nitrate ($\text{H}_2\text{N}_2\text{O}_6$), *Hydric Nitrate*, *Nitric Acid*, or *Aqua Fortis*. This acid was known as early as the eighth century, but its true composition was first stated by Cavendish, in the year 1785.

Preparation. By distilling Potassium Nitrate ($\text{K}_2\text{N}_2\text{O}_6$), or Sodium Nitrate ($\text{Na}_2\text{N}_2\text{O}_6$) with Hydric Sulphate (H_2SO_4). The Sodium salt being generally selected. $(\text{Na}_2\text{N}_2\text{O}_6) + (\text{H}_2\text{SO}_4) = (\text{Na}_2\text{SO}_4) + (\text{H}_2\text{N}_2\text{O}_6)$.

Properties. This acid is without color when pure, the commercial variety having a slight yellow tinge. Nitric Acid has a specific gravity of 1.52, freezes at a low temperature, and boils at 184° .

Test. It reddens Litmus, Morphia, Narcotina and Brucia.

AMMONIUM (N H_4).

A compound radical, acting the part of a monad. When sodium amalgam is placed in a saturated solution of ammonium chloride ($\text{N H}_4\text{Cl}$) a spongy mass results, of considerable bulk, which is supposed to be ammonium amalgam; it quickly disappears, however, ammonia (N H_3) escaping, mercury, Hg, and sodium chloride, NaCl, remaining, the latter in solution.

AMMONIA (N H_3).

This compound was known as early as the thirteenth century, but was first shown as a gas by *Priestley*, in the year 1774, and called by him alkaline air. It is made by double decomposition between ammonium chloride (NH_4Cl) with calcic oxide, Ca O. $(\text{Ca O}) + 2(\text{N H}_4\text{Cl}) = \text{Ca Cl}_2 + 2\text{N H}_3 + \text{H}_2\text{O}$, or $(\text{N H}_4)_2\text{O}$.

Properties. A gas without color, capable of being liquefied and solidified; has a pungent odor and is freely soluble in water (H_2O) that liquid taking up 700 times its volume at (32°F) .

Test. Nessler's solution. This solution is prepared thus: 50 grams of potassium iodide are dissolved in a small quantity of boiling distilled water, in a basin placed on a water bath. Hot saturated solution of mercuric chloride is then added, with constant stirring, until a slight permanent red precipitate is produced. The solution thus obtained is filtered and mixed with 200 grams of potassium hydrate dissolved in the smallest possible quantity of distilled water. When the whole is quite cold it is made up with cold distilled water to the bulk of one liter; and 5 c. c. of a cold saturated solution of mercuric chloride having been added, the solution is well shaken, and then left to settle. Lastly, the clear portion is decanted and kept for use. (*Müter's Analytical Chemistry, 3d Ed., 1880, page 190.*)

AMMONIUM CHLORIDE, $N H_4 Cl$.

Sometimes found native, but usually prepared by adding hydric chloride ($H Cl$) to gas liquor (which is formed in the manufacture of illuminating gas), evaporating and purifying by sublimation.

Also from the destructive distillation of bones in the manufacture of animal charcoal.

Properties. It is white, fibrous, and soluble in water.

AMMONIUM SULPHATE, $(N H_4)_2 SO_4$.

Obtained in a mannner similar to the chloride, or by adding hydric sulphate (H_2SO_4) to ammonium carbonate to neutrality.

Properties. It is soluble in water ($H_2 O$) and crystallizes in long, flattened, six-sided prisms. (Fownes.)

AMMONIUM NITRATE, $(N H_4)_2 N_2 O_6$.

Is made by neutralizing dilute hydric nitrate ($H_2 N_4 O_6$) with ammoniac carbonate, and crystallizing by evaporation at a low temperature.

Properties. Soluble in cold water and decomposed by heat.

AMMONIUM PHOSPHATE, $2 H_2 (N H_4)_2 P_2 O_8$.

Prepared by adding ammonium carbonate to a solution of dihydric calcic phosphate ($Ca 2 H_2 P_2 O_8$). Calcic carbonate falls as a precipitate, which is separated by filtration, and the solution evaporated. $Ca 2 H_2 P_2 O_8 + (N H_4)_2 CO_3 = 2 H_2 (N H_4)_2 P_2 O_8 + Ca CO_3$.

Properties. This salt is decomposed by heat, ammonia ($N H_3$) escaping, and trihydrated phosphoric acid ($3 H_2 P_2 O_8$) remaining, provided the temperature is not too high; should this be the case, dihydric, or even monohydric phosphate would result.

AMMONIUM CARBONATES.

There are several, the most common being the dicarbonate ($(N H_4)_2 CO_3 H_2 CO_3$), which is made by saturating ammoniac hydrate (NH_3), $H_2 O$ or $(N H_4)_2 O$ with carbonic anhydride (CO_2). It has also been found native in guano.

Properties. It is soluble in water, insoluble in alcohol.

CARBON.

Symbol C. Combining weight 12.

Found native in two forms, the diamond and as graphite. The various varieties of mineral coal, charcoal and lampblack, are also examples of this element, but in different forms of purity. The specific gravity of the diamond is 3.5, of graphite 2.2.

Properties. In the form of a diamond, carbon is a solid body of great hardness, having several crystalline forms, and is used in the arts for various

purposes. When cut with the appropriate number of sides, and of the proper shape, it becomes an ornament of considerable value, and possessing great refractive power.

Graphite. This form of carbon is largely used in making pencils, also crucibles. The more common forms of the element are too well known to require any explanation of their properties.

OXYGEN COMPOUNDS.

Carbon Monoxide, or *Carbonic Oxide* (CO). Specific gravity .967. One liter weighs 1.251 grm. 100 cubic inches weighs 30 grs.

Discovered by *Priestley* in the year 1787, and made by decomposing Hydric Oxalate, or Oxalic acid ($\text{H}_2\text{C}_2\text{O}_4$), by Hydric Sulphate (H_2SO_4). Carbonic oxide (CO), Carbonic anhydride (CO_2) and water (H_2O) are formed, the gases being passed through lime water ($\text{Ca O H}_2\text{O}$), Calcic Carbonate (Ca CO_3) remaining as an insoluble body, and Carbonic Oxide passes off.

Properties. A poisonous gas, without color, odor or taste, burning with a blue flame, and generating Carbonic Anhydride (CO_2).

Test. Its burning producing Carbonic Anhydride.

Carbon Dioxide, or Carbonic Anhydride CO_2 . Specific gravity 1.524. One liter weighs 1.966 grm. 100 cubic inches weighs 47 grs.

Discovered by *Black* in the year 1756, and can be obtained from several sources, the principal of which are caves, springs, combustion, fermentation and chemical action. This gas is generally prepared by decomposing Calcic Carbonate (Ca CO_3) by Hydric Chloride, H Cl , Calcic Chloride and water (H_2O) being formed, and Carbonic Anhydride given off. $\text{Ca CO}_3 + 2\text{H Cl} = \text{Ca Cl}_2 + \text{H}_2\text{O} + \text{CO}_2$.

Properties. A colorless gas, with a peculiar odor and taste, capable of being liquefied, soluble in water, and very poisonous.

Test. Calcic Hydrate, $\text{Ca O H}_2\text{O}$, gives a white precipitate.

HYDROGEN COMPOUNDS.

These are many in number; two only are given here, both being gases.

Ethene, **Heavy Carbo-hydrogen**, or *Olefant gas* (C_2H_4). Specific gravity .981. One liter weighs 1.252 grm. 100 cubic inches weighs 30 grs.

Discovered by *Dutch chemists* in the year 1796, and made by decomposing alcohol ($\text{C}_2\text{H}_6\text{O}$) by hydric sulphate (H_2SO_4). $\text{C}_2\text{H}_6\text{O} + \text{H}_2\text{SO}_4 = \text{H}_2\text{O} + \text{H}_2\text{SO}_4 + \text{C}_2\text{H}_4$.

Properties. A combustible, colorless gas, with an unpleasant odor. One of the constituents of illuminating gas. The products of its combustion

tion being water (H_2O) and carbon anhydride (CO_2). Ethene is soluble in water, to a slight extent.

Test. Chlorine, which forms an oily liquid.

Methane, Light Carbo-hydrogen, or Marsh gas (CH_4). Specific gravity .557. One liter weighs .715 grm. 100 cubic inches weighs .17 grs.

Discovered by *Dumas* and obtained by heating a mixture of sodium C_2H_3 acetate ($NaCH_3O_2$) with sodic hydrate ($NaHO$). $(NaC_2H_3O_2) + (NaHO) = (Na_2CO_3) + (CH_4)$.

Properties. A colorless, odorless, tasteless gas; slightly soluble in water, and combustible, the products being water (H_2O) and carbonic anhydride (CO_2). When mingled with air it forms an explosive mixture, to which many of the coal mine accidents may be attributed.

COMPOUNDS OF CARBON AND NITROGEN.

Cyanogen (CN) or (Cy).

Discovered by *Gay-Lussac* in the year 1841, and is prepared by heating *mercuric cyanide* ($HgCy_2$). $HgCy_2 = Hg + 2Cy$. A univalent radical.

Properties. A poisonous, colorless, inflammable gas, that burns with a purple flame, having a specific gravity of 1.806.

Hydrogen Cyanide, Hydro-cyanic, or Prussic acid (HCy).

Discovered by *Scheele* in the year 1782, and prepared in a state of purity and anhydrous by decomposing mercuric cyanide, $HgCy_2$, with hydrogen sulphide, H_2S . $HgCy_2 + H_2S = HgS + 2HCy$. The gas is condensed by cold, in a receiver, to a liquid form. When pure, this acid is thin, colorless, and very volatile, having a specific gravity of .7058. Though one of the most poisonous substances known, yet it is used in medicine, the *two per cent. acid* being official, and is made by the action of hydric sulphate, H_2SO_4 , on potassium ferro-cyanide, K_4FeCy_6 .



Properties. A colorless liquid, exceedingly poisonous.

Tests. An iron salt with potassic hydrate gives Prussian blue. Argentic nitrate gives white precipitate, insoluble in ammonia. Ammonic sulphide and a persalt of iron give blood-red.

Cyanic $CNH O$, **Cyanuric** $C_3N_3H_3O_3$, and **Fulminic Acids** $C_2N_2H_2O_2$, are known, but are of little importance to the medical student.

SULPHUR.

Symbol S. **Combining weight** 32.

Specific gravity 1.98–2.04. **Of the vapor** 2.22. One liter weighs 2.867 grms.

This element has been long known, and is found contaminated by earthy impurities in various parts of the world, principally in the neighborhood of active or extinct volcanoes. Sulphur may be a negative or positive hexad.

Preparation. It is purified by sublimation, melted, and poured into molds. *Roll Sulphur* or *Brimstone* is then produced; this, when sublimed, constitutes *Flowers of Sulphur*, and when washed, the *Sulphur lotum* of the druggist.

Properties. A yellow, solid body, insoluble in water and alcohol; oil of turpentine and fat oils dissolve it, but the best solvent is Carbon Disulphide. Sulphur melts at 232° F., and boils at 792° F. It exists in several allotropic forms.

OXYGEN COMPOUNDS.

There are two Oxides of Sulphur, having the names and composition as follows:—

Sulphur Dioxide..... SO_2 .

Sulphur Trioxide..... SO_3 .

These oxides combine with the elements of water, and become the prominent acids.

Hydrogen Sulphite,
or Sulphurous Acid, } $\text{H}_2 \text{SO}_3$.

AND

Hydrogen Sulphate,
or Sulphuric Acid, } $\text{H}_2 \text{SO}_4$.

$\text{SO}_2 + \text{H}_2 \text{O} = \text{H}_2 \text{SO}_3$ or *Sulphurous Acid*.

$\text{SO}_3 + \text{H}_2 \text{O} = \text{H}_2 \text{SO}_4$ or *Sulphuric Acid*.

The following are also oxygen compounds of Sulphur that are acids.

Hydrogen Hyposulphite,
or Hyposulphurous Acid, } $\text{H}_2 \text{SO}_2$.

And the *Polythionic group*.

Dithionic Acid..... $\text{H}_2 \text{S}_2 \text{O}_6$.

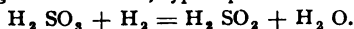
Trithionic Acid..... $\text{H}_2 \text{S}_3 \text{O}_6$.

Tetrathionic Acid..... $\text{H}_2 \text{S}_4 \text{O}_6$.

Pentathionic Acid..... $\text{H}_2 \text{S}_5 \text{O}_6$.

Hydrogen Hyposulphite, $\text{H}_2 \text{SO}_2$ or Hyposulphurous Acid.

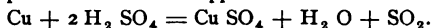
"This compound was discovered by *Schützenberger*, and called by him hydrosulphurous acid. It is obtained by the action of metallic iron or zinc on sulphurous acid contained in a closed vessel; no evolution of hydrogen takes place in this case, as the gas at once combines in the nascent condition with the oxygen to form water, hyposulphurous acid being formed; thus



"A deep yellow-colored liquid is thus obtained, possessing powerful reducing properties. It bleaches organic coloring matter more quickly than sulphurous acid, and precipitates the metals silver and mercury from solutions of their soluble salts." (Roscoe and Schörllemmer.)

Sulphur Dioxide, SO_2 , or *Sulphurous Anhydride*.

This gas may be prepared by burning sulphur in dry oxygen, or by heating hydric sulphate with metallic copper.



Properties. It is a colorless gas with a peculiar, suffocating odor, and very irrespirable. Its specific gravity is 2.21. One liter weighs 2.8605 grms. 100 cubic inches weighs 68.69 grains. At 0°F ., it condenses into a colorless liquid, which, when exposed to a current of air, evaporates so quickly as to cause great cold. It is soluble in water and imparts to that liquid acid properties.

Sulphur Trioxide, SO_3 , or *Sulphuric Anhydride*.

May be obtained by distilling Nordhausen sulphuric acid, and collecting in a cold receiver.

Properties. A white crystalline body having a specific gravity of 2.77.

Hydrogen Sulphate, $\text{H}_2 \text{SO}_4$, Sulphuric Acid or *Oil of Vitriol*.

This important acid was known in the fifteenth century, and is made in large rooms especially prepared for the purpose, by being thoroughly sheathed with lead, and provided with openings for the admission of air and steam; water covering the floor to the depth of several inches. The product of burning sulphur (sulphurous anhydride SO_2) enters the chamber, where it meets with hyponitric anhydride ($\text{N}_2 \text{O}_4$) and steam. A complicated rearrangement of the elements now takes place, resulting in the formation of other bodies, but especially of hydric sulphate in a dilute form; this is drawn off and concentrated, first in shallow vats lined with lead, and secondly, in vessels of glass or platinum, until the liquid arrives at the proper specific gravity.

Properties. A heavy, colorless, oily liquid, having the specific gravity of 1.85. It is a powerful acid, very corrosive, carbonizing organic matter when brought in contact with it. Commercial sulphuric acid usually contains lead.

Test. A soluble salt of Barium, as the Chloride, gives a white precipitate.

CHLORINE COMPOUNDS OF SULPHUR.

<i>Sulphur Monochloride</i>	$\text{S}_2 \text{Cl}_2$.
<i>Sulphur Dichloride</i>	S Cl_2 .
<i>Sulphur Tetrachloride</i>	S Cl_4 .

Sulphur Monochloride, $S_2 Cl_2$. Is made by passing a current of dry chlorine gas over hot flowers of sulphur.

Properties. It is a dark yellow, oily liquid.

Sulphur Dichloride, $S Cl_2$. Is made by passing chlorine gas into the monochloride.

Properties. A liquid of a dark reddish-brown color.

Sulphur Tetrachloride, $S Cl_4$. When the dichloride is surrounded by a freezing mixture and saturated with chlorine gas, the tetrachloride is formed.

Properties. A light yellow liquid, very unstable.

IODINE COMPOUNDS OF SULPHUR.

Sulphur Moniodide..... $S_2 I_2$.

Sulphur Hexiodide..... $S I_6$.

Sulphur Moniodide, $S_2 I_2$. Is made by heating Sulphur and Iodine together.

Properties. It is a dark gray crystalline solid.

Sulphur Hexiodide, $S I_6$. "It is formed when a solution of iodine and sulphur in carbon disulphide is evaporated." (Landolt and vom Rath.)

SULPHUR AND BROMINE.

Bromine Disulphide..... $Br_2 S_2$.

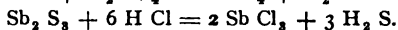
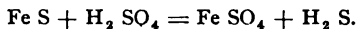
It is prepared by dissolving sulphur in an excess of bromine, and volatilizing the excess with dry carbonic anhydride.

Properties. A light red liquid body.

SULPHUR AND HYDROGEN.

Hydrogen Persulphide, $H_2 S_2$. (Composition not well known.)

Hydrogen Monosulphide, $H_2 S$, or Sulphuretted Hydrogen. It is best prepared by acting on the sulphides of iron or antimony with dilute hydric sulphate or hydric chloride.



Discovered by Scheele in the year 1777.

Properties. A colorless gas, of an unpleasant odor, soluble in water, to which it imparts acid properties. Burns with a pale blue flame, forming water and sulphur dioxide. Poisonous when inhaled, and explosive when mixed with air and ignited. It may be liquefied at a pressure of seventeen atmospheres. This gas will decompose many of the soluble

metallic salts, producing mostly black precipitates, the sulphides of the metals.

Sulphuretted hydrogen has a specific gravity of 1.175. One liter weighs 1.52 grms. 100 cubic inches weighs 35 grains.

PHOSPHORUS.

Symbol P. Combining weight 31.

Specific gravity 1.77. Of the vapor 4.32. Of amorphous 2.106. One liter weighs 5.542 grms.

Discovered by *Brandt* in the year 1669. In 1769, one hundred years later, *Scheel* and *Gahn* discovered it in bones, and devised a method of obtaining it.

Preparation. Phosphorus is obtained by acting on burned bone or tricalcic phosphate, $\text{Ca}_3\text{P}_2\text{O}_8$, with hydric sulphate, H_2SO_4 ; evaporating and dissolving out the calcic hydric phosphate with water. This solution is now evaporated to dryness and the solid residue fired, when metaphosphate of calcium is formed; this, when mingled with carbon and silicic acid (sand) and subjected to high heat, furnishes phosphorus, which is condensed under water. To free it from impurities, it is squeezed through chamoix leather while in a liquid condition, under water, and cast into rods.

$\text{Ca}_3\text{P}_2\text{O}_8 + 2\text{H}_2\text{SO}_4 = 2\text{CaSO}_4 + \text{Ca}_2\text{H}_2\text{P}_2\text{O}_8$. $\text{Ca}_2\text{H}_2\text{P}_2\text{O}_8 + \text{heat} = 2\text{H}_2\text{O} + \text{CaP}_2\text{O}_6$. $\text{CaP}_2\text{O}_6 + \text{SiO}_2 + 5\text{C} = 5\text{CO} + \text{CaSiO}_3 + 2\text{P}$.

Properties. It is a colorless, transparent, waxy solid, melting at 110° F. and boiling at 536° F. Soluble in alcohol, ether, oils and carbon disulphide. It is very combustible and is to be kept under water. This element, though used as a medicine, is very poisonous. Phosphorus exists in two well defined allotropic forms, the normal and red, or amorphous.

AMORPHOUS PHOSPHORUS.

This form of Phosphorus was discovered in 1848, by *Schrötter*, and is prepared by heating the normal variety in nitrogen gas for several days, at a temperature of 470° F.

Properties. Insoluble, and having a specific gravity of 2.14.

OXYGEN COMPOUNDS OF PHOSPHORUS.

Phosphorus Trioxide..... P_2O_3 .

Phosphorus Pentoxide..... P_2O_5 .

Both of these are acid oxides, uniting with water, and forming phosphorus and phosphoric acids. There is another oxygen acid of phosphorus, having a less quantity of oxygen, called hypophosphorous acid.

Hydrogen Hypophosphite, H_2PO_2 , or *Hypophosphorous Acid*. This acid is prepared by first forming barium hypophosphite, and decomposing it with hydric sulphate; barium sulphate remains as an insoluble body, and the acid is separated by filtration and concentrated by evaporation. This acid forms soluble salts.

Hydrogen Phosphite, H_2PO_3 , or *Phosphorous Acid*. Prepared by decomposing phosphorus trichloride with water; evaporating and heating the residue; when cold the acid crystallizes.

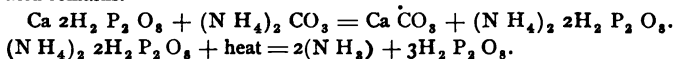
Properties. The crystalline acid absorbs moisture and undergoes decomposition, hydrogen phosphide and phosphoric acids being formed.

Hydrogen Phosphate, or *Phosphoric Acid*. This acid may be considered as capable of existing in three conditions, namely:—

Orthophosphoric Acid,	}	$3\text{H}_2\text{P}_2\text{O}_8$ <i>Tribasic</i> .
Trihydric Phosphate,		
Pyrophosphoric Acid,	}	$2\text{H}_2\text{P}_2\text{O}_8$ <i>Bibasic</i> .
Dihydric Phosphate,		
Metaphosphoric Acid,	}	$\text{H}_2\text{P}_2\text{O}_6$ <i>Monobasic</i> .
Monohydric Phosphate,		

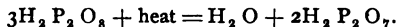
TRIHYDRIC PHOSPHATE, $3\text{H}_2\text{P}_2\text{O}_8$.

Preparation. A solution of calcic hydric phosphate, $\text{Ca } 2\text{H}_2\text{P}_2\text{O}_8$, is treated with ammonium carbonate $(\text{NH}_4)_2\text{CO}_3$; ammoniac hydric phosphate is formed, which, when evaporated and heated, suffers decomposition, ammonia, NH_3 , passing off, and ortho, tribasic or trihydric phosphoric acid remains.



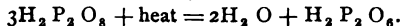
DIHYDRIC PHOSPHATE, $2\text{H}_2\text{P}_2\text{O}_7$.

Preparation. When trihydric phosphate is heated to the proper temperature in a platinum vessel, one molecule of water is driven off, and dihydric phosphate remains.



MONOHYDRIC PHOSPHATE, $\text{H}_2\text{P}_2\text{O}_6$.

When orthophosphoric or trihydrated acid is fired, two molecules of water are driven off and the monohydric acid remains.



This form of acid, sometimes called *glacial*, may also be made by the action of hydric nitrate on phosphorus.

Test. Molybdate of ammonium in solution with a little hydric nitrate gives a yellowish-brown precipitate.

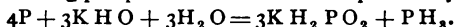
Phosphoric Anhydride, P_2O_5 . This acid oxide is formed when phosphorus is burned in dry oxygen. A snow-white solid is produced, which has a great affinity for water.

HYDROGEN COMPOUNDS.

There are three compounds of hydrogen and phosphorus known. A gas H_2P ; a liquid H_4P_2 ; a solid H_2P_4 .

The first named, being of sufficient importance, is the one described.

Hydrogen Phosphide or Phosphine, H_2P . Discovered in the year 1783 by *Gengembre*, and made by the action of water on calcium phosphide, or by heating phosphorus with a solution of potassic hydrate.



Properties. A spontaneously inflammable gas, burning with a bright light, forming water and phosphoric anhydride. It has a garlic-like odor, and a specific gravity of 1.24. One liter weighs 1.52 grams.

COMPOUNDS OF PHOSPHORUS AND CHLORINE.

These are two in number, and are as follows:—

Phosphorus Trichloride..... $P Cl_3$.

Phosphorus Pentachloride..... $P Cl_5$.

Phosphorus Trichloride, $P Cl_3$ is made by passing a steam of dry chlorine over phosphorus, heated in a tubulated retort. Condensation in a cold receiver furnishes a liquid.

Properties. It is a liquid, without color, having a specific gravity of 1.45.

Phosphorus Pentachloride, $P Cl_5$. When phosphorus trichloride is treated with an excess of chlorine, two more atoms of that gas combine, and a yellow crystalline solid results.

COMPOUNDS OF PHOSPHORUS AND BROMINE.

There are two of these compounds, and are as follows:—

Phosphorus Tribromide..... $P Br_3$.

Phosphorus Pentabromide..... $P Br_5$.

COMPOUND OF PHOSPHORUS AND IODINE.

Phosphorus Triiodide..... $P I_3$.

The compounds of bromine and iodine with phosphorus are of little value, and are of interest only to those who make chemistry an exclusive study.

COMPOUNDS OF PHOSPHORUS AND SULPHUR.

These are several in number, the following being mentioned, though of very little importance:—

Phosphorus Trisulphide..... P_2S_3 .

Phosphorus Pentasulphide..... P_2S_5 .

SELENIUM.

Symbol Se. Combining weight 79.5. Specific gravity 4.3 when vitreous, 4.8 when crystallized.

Discovered by *Berzelius* in the year 1817.

This element, like sulphur, exists in two forms, one crystalline the other amorphous, and is found in certain Swedish pyrites. It is obtained by the action of water and sulphurous anhydride on selenious acid.

COMPOUNDS OF SELENIUM AND CHLORINE.

Selenium Monochloride..... $\text{Se}_2 \text{Cl}_2$.

Selenium Tetrachloride..... Se Cl_4 .

These salts are made by processes similar to the chlorides of Sulphur.

COMPOUNDS OF SELENIUM AND BROMINE.

Selenium Monobromide..... $\text{Se}_2 \text{Br}_2$.

Selenium Tetrabromide..... Se Br_4 .

COMPOUNDS OF SELENIUM AND IODINE.

Selenium Monoiodide..... $\text{Se}_2 \text{I}_2$.

Selenium Tetraiodide..... Se I_4 .

The iodides of selenium resemble the chlorides and bromides, and are made by processes somewhat similar.

COMPOUNDS OF SELENIUM AND OXYGEN.

Oxide.

Selenium Dioxide..... Se O_2 .

Acids.

Hydrogen Selenite, } $\text{H}_2 \text{ Se O}_3$.

Selenious Acid, }

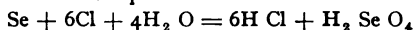
Hydrogen Selenate, } $\text{H}_2 \text{ Se O}_4$.

Selenic Acid, }

Selenium Dioxide, Se O_2 , is formed when selenium is heated in a current of dry oxygen.

Hydrogen Selenite, $\text{H}_2 \text{ Se O}_3$, or *Selenious Acid*. This acid is made by the action of Hydric Nitrate on Selenium.

Hydrogen Selenate, $\text{H}_2 \text{ Se O}_4$, or *Selenic Acid*. This acid was discovered by *Mitscherlich*, in the year 1827, and is obtained by the action of chlorine on selenium in the presence of water.



TELLURIUM.

Symbol Te. Combining weight 128. Specific gravity 6.26. Was discovered by *Klaproth* in 1798, and belongs to the rarer elements.

Though sometimes found in small quantities in a free state, it is generally met with associated with gold, silver, lead and bismuth, as tellurides.

Properties. It is a bluish-white body, with a metallic lustre, melting at 500° , and combining with hydrogen, chlorine, bromine, iodine, fluorine, oxygen and sulphur, forming compounds similar to those of selenium.

Carbon, sulphur, phosphorus, selenium and tellurium, though belonging to the non-metallic group of elements, from the similarity of their chemical and physical constituents, are sometimes called combustibles.

ARSENICUM.

Symbol *As*. Combining weight 75. Specific gravity 5.7.

Discovered by *A. Schröder* in the year 1694.

Though sometimes found native, it generally occurs as a compound in minerals, combined with metals, sulphur and oxygen. As an oxide it has been found in minute quantities in the water of many mineral springs.

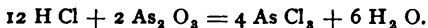
Preparation. This element is usually prepared by sublimation from the sulph-arsenide of iron, known as *mispickel* (Fe As S), iron sulphide remaining, and the arsenic condensing in a crystalline form. It is purified by re-sublimation.



Properties. Arsenic is volatile, crystalline and brittle; has a high metallic lustre, and a steel-gray color.

ARSENIC TRICHLORIDE, As Cl_3 .

Preparation. It is obtained by passing dry chlorine over heated arsenic; or, by heating to the boiling point of water 40 parts of arsenic trioxide with 100 of hydric sulphate, in an apparatus connected with a well cooled receiver. Small pieces of fused sodium chloride are then carefully thrown in, when the chloride distills over.



(Roscoe and Schörlammer).

Triiodide As I_3 , Tribromide As Br_3 , and Trifluoride of arsenic are also known, but are interesting only to the advanced chemical student.

ARSENIC AND SULPHUR.

There are three sulphides of arsenic, and are as follows:—

<i>Arsenic Disulphide</i> (<i>Realgar</i>)	$\text{As}_2 \text{ S}_2$.
<i>Arsenic Trisulphide</i> (<i>Orpiment</i>).....	$\text{As}_2 \text{ S}_3$.
<i>Arsenic Pentasulphide</i>	$\text{As}_2 \text{ S}_5$.

Arsenic Disulphide, $\text{As}_2 \text{ S}_2$. Found native as *realgar*; is prepared chemically by heating arsenic acid with the proper quantity of sulphur.

Arsenic Trisulphide, As_2S_3 . Found native as orpiment; is prepared chemically by precipitation; hydrogen sulphide being passed into a solution of arsenious acid.

Arsenic Pentasulphide, As_2O_5 , is best prepared by fusing the trisulphide in proper amount with sulphur.

ARSENIC AND OXYGEN.

Arsenic combines with oxygen in two proportions, producing two acid-forming oxides, viz :—

Arsenic Trioxide..... As_2O_3 .

Arsenic Pentoxide..... As_2O_5 .

Arsenic Trioxide, As_2O_3 , or *Arsenious Oxide*. This poisonous body is generally obtained by roasting arsenical minerals, particularly mispickel. The impure arsenious oxide thus prepared is then re-sublimed.

Properties. It is dimorphous, that is, it exists in two forms, the vitreous and opaque. Arsenious oxide crystallizes in regular octahedra, or in tetrahedra. It is slightly soluble in cold water, the vitreous being more so than the other variety. It is almost without taste, when in solution, and slightly reddens litmus blue. Specific gravity 3.738.

Arsenic Pentoxide, As_2O_5 , or *Arsenic Oxide*. When powdered arsenious oxide is dissolved in hot hydrochloric acid, and oxidized by the addition of nitric acid, the latter being added as long as red vapors are produced, the whole then cautiously evaporated to complete dryness, and the residue heated to low redness, arsenic oxide, As_2O_5 , remains, in the form of a white anhydrous mass which has no action on litmus. In water it dissolves slowly but completely, giving a highly acid solution, which, on being evaporated to a syrupy consistence, deposits, after a time, hydrated crystals of arsenic acid, AsO_4H_3 .

All of the compounds of arsenic, when taken internally, are poisonous, and if applied locally, cause excitation.

Tests. When arsenic is present in an appreciable quantity, the following liquid tests will respond, as follows, viz :—

Ammonio-Arsenite solution.	{	<i>Yellow</i>
Result—(Arsenite of Silver).		precipitate.
Ammonio-Cupric Sulphate solution.	{	<i>Green</i>
Result—(Arsenite of Copper).		precipitate.
Hydrogen Sulphide solution.	{	<i>Yellow</i>
Result—(Arsenic Sulphide).		precipitate.

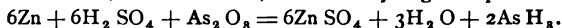
Reinsch's is the addition of hydric chloride, application of heat, and immersing a small sheet of clean copper foil in the liquid. A steel-gray coating forms on the surface of the copper.

Marsh's is the formation of *arseniuretted hydrogen*, lighting it, and cooling its flame on the surface of cold, white porcelain; a blackish spot is produced, which, if arsenic, will dissolve in a solution of sodium hypochlorite.

This test has been modified, and consists in passing a stream of the dry gas through a horizontal tube of hard glass, which can be heated at any point along its length; the result being the formation of a black ring just beyond the point of heating. The tube is now to be cut of the proper length, care being taken that it shall contain the ring, and heat applied; it quickly disappears, a white ring forming on a cool part of the tube, which the microscope shows to be composed of octahedral crystals.

Hydrogen Arsenide, As H_3 , or *Arseniuretted Hydrogen*.

Preparation. This gas can be obtained by the combined action of pure metallic zinc, arsenious oxide, water and hydrogen sulphate.



Properties. It is an extremely poisonous gas, without color, and of a garlicky odor.

Reduction. When a mixture of an arsenical salt and powdered black flux* is heated in a closed tube of glass†, arsenic, in its elementary form, is deposited as a black ring, some little distance above the heated mass. When the closed end is cut, the contents shaken out, and heat applied to the ring, it will disappear, a white one forming on a cooler part; if now examined under the microscope, octahedral crystals of arsenious oxide will be seen.

BORON.

Symbol B. Combining weight 11. Specific gravity 2.68.

Discovered in the year 1807, by *Davy*.

Preparation. Amorphous boron is obtained by heating the double fluoride of boron and potassium with sodium. It is a dark, greenish-brown powder. By dissolving it in melted aluminium, cooling, and removing the aluminium by hydrogen chloride, a crystalline variety is prepared, which varies in color from yellow to light red.

* *Black flux* is prepared by burning *potassium acid tartrate*, $\text{H K (C}_4\text{H}_4\text{O}_6)$, in a crucible. Chemically it is an intimate mixture of carbon and potassium carbonate.

† Glass tubing used in arsenic examinations should be entirely free from lead.

Properties. Nearly as hard and refractive as the diamond. Infusible in the oxy-hydrogen flame, but burns in oxygen.

A trichloride $B Cl_3$, tribromide $B Br_3$ and trifluoride $B F_3$, are compounds of boron known to exist, and are obtainable by appropriate methods.

BORON AND OXYGEN.

There is but one oxide of boron, viz: *boric oxide* $B_2 O_3$.

HYDROGEN BORATE, $H_3 B O_3$, or BORACIC ACID.

Discovered in the year 1702, by *Homburg*. It is found in the waters of the hot springs of Tuscany, but can be obtained chemically by decomposing a solution of sodium biborate with hydric sulphate.

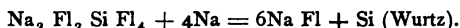
Properties. It crystallizes in colorless scales, soluble in water and alcohol.

SILICON.

Symbol Si. Combining weight 28. Specific gravity 2.49.

Discovered in the year 1825, by *Berzelius*.

Preparation. Amorphous Silicon. When well dried sodium fluosilicate is heated with half its weight of metallic sodium, sodium fluoride is formed, and silicon set free.



Dewille and *Caron* obtained a crystalline variety by heating a mixture of potassium and sodium double fluoride, zinc and sodium.

SILICIC ANHYDRIDE, $Si O_2$, or SILICA.

Preparation. It is prepared by burning silicon, or dehydrating silicic acid.

Properties. As obtained chemically, silica is a white amorphous powder. Found native as quartz, agate, chalcedony, cornelian, flint, sand, etc. It has a specific gravity of 2.6, is insoluble in water, and enters into the composition of glass.

HYDROGEN SILICATE, $H_4 Si O_4$, or SILICIC ACID.

Discovered by *Buff* and *Wohler*.

Preparation. This acid may be prepared by the action of water on silicon fluoride, or by decomposing a soluble alkaline silicate with an acid.

Properties. It is a colorless, tasteless liquid; slightly acid, and liable to gelatinize.

Silicon forms compounds with the electro-negative elements, Chlorine, Iodine, Bromine and Fluorine.

CHEMISTRY OF THE METALS.

The second group, or metals, contains the largest number of elements. Several were known to the ancients, but most of them were discovered during the eighteenth century.

CLASSIFICATION OF METALS.

Metals have been classified, according to their atomicity or quantivalence, into several classes; and these classes divided into groups, the members of each group having certain chemical and physical characters in common.

<i>Class 1st, Monad Metals.</i>	<i>Class 2d, Dyad Metals.</i>	<i>Class 3d, Triad Metals.</i>
Potassium. Sodium. Lithium. Rubidium. Cæsium. Silver.	Calcium. Strontium. Barium. Glucinum. Yttrium. Lanthanum. Didymium. Erbium. Thorium. Magnesium. Zinc. Cadmium. Copper. Mercury.	Gold. Thallium.
<i>Class 4th, Tetrad Metals.</i>	<i>Class 5th, Pentad Metals.</i>	<i>Class 6th, Hexad Metals.</i>
Titanium. Tin. Aluminium. Zirconium. Rhodium. Ruthenium. Palladium. Platinum. Iridium. Osmium. Lead. Manganese. Iron. Cobalt. Nickel. Cerium. Indium. Uranium.	Vanadium. Antimony. Bismuth. Niobium. Tantalum.	Tellurium. Chromium. Molybdenum. Tungsten.

Physical Properties. The most striking are their lustre, color, density, malleability, ductility, and high melting point. The metals are electro-positive and good conductors of heat and electricity.

Chemical Properties. The formation of alloys and amalgams. Their uniting with the electro-negative elements, especially oxygen, producing compounds that may be oxides, acids, alkalies, alkaline earths, and earths.

CLASS 1ST, MONAD METALS.

POTASSIUM.

Symbol K (Kallium). Combining weight 39.1. Specific gravity .865.

Preparation: Potassium is obtained by heating, in a proper vessel, a mixture of potassium carbonate and carbon. The metal is condensed, carbon monoxide passing off as a gas. The operation is attended with some danger, and therefore requires skillful attention.

Properties. Potassium is a white metal, with considerable lustre; at ordinary temperatures it is soft, and can be easily cut, but at 0° it is hard and crystalline. It melts at 62.5° and distills at a red heat.

Potassium promptly oxidizes when exposed to the air, and is, therefore, to be kept under naphtha. When thrown upon water it takes fire, and burns with a purple flame.

POTASSIUM CHLORIDE, K Cl.

Preparation. It can be obtained from sea water by the process of *M. Balard*. Considerable quantities are procured from the salt beds near Staasfurt, Germany, where it exists associated with magnesium as a double chloride of potassium and magnesium as a natural deposit. This salt is also formed in large quantity in the manufacture of potassium chlorate.

Properties. Potassium chloride resembles sodium chloride in color, taste and crystalline form. It is soluble in water, fuses at a red heat, and volatilizes at a higher temperature. Its specific gravity is 1.9.

POTASSIUM BROMIDE, K Br.

Preparation. This salt, together with the bromate, is obtained when potassic hydrate is added to the ethereal solution of bromine, which is made in one of the steps for procuring bromine, as already described. (See Bromine.)

Properties. This salt is without color, very soluble in water, and crystallizes in cubes, which have a saline taste.

POTASSIUM IODIDE, K I.

Preparation. This salt, together with the iodate, is formed in the manufacture of iodine. (See Iodine, page 22.)

Properties. Potassium iodide crystallizes in cubes, which are generally of a milk-white color; they are without water, and fusible by heat. This salt is soluble in water, and dissolves free iodine in considerable quantity.

OXYGEN COMPOUNDS OF POTASSIUM.

There are three oxygen compounds of potassium :—

Potassium Monoxide..... $K_2 O$.

Potassium Dioxide $K_2 O_2$.

Potassium Tetroxide..... $K_2 O_4$.

POTASSIUM MONOXIDE, $K_2 O$.

Preparation. This compound is formed when potassium in thin pieces is exposed to perfectly dry air that is free from carbon dioxide.

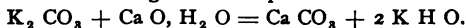
Properties. It is a whitish substance, very deliquescent and caustic; unites with water with great energy, forming potassium hydrate.

Potassium Dioxide, $K_2 O_2$, and *Potassium Tetroxide*, $K_2 O_4$.

These two substances are but little known.

POTASSIUM HYDRATE, $K H O$.

Preparation. This important compound is formed by the action of calcium hydrate on a boiling solution of potassium carbonate.



Calcium carbonate remains as an insoluble substance, together with the excess of lime; the potassium hydrate in solution, with some lime, is drawn off and evaporated. Thus prepared it is impure, from the presence of lime; to purify it, dissolve in alcohol, evaporate in silver vessel, melt, and pour into moulds.

Properties. It is a white substance, soluble in water and alcohol, very caustic, and the strongest of the alkaline bodies. It has a density of 2.1, rapidly combines with carbonic acid, and is therefore to be kept excluded from the air. It also absorbs moisture with avidity.

POTASSIUM CARBONATES.

There are two carbonates of potassium, both being well known. One is neutral, the other acid.

POTASSIUM NEUTRAL CARBONATE, $K_2 CO_3$.

Preparation. It is obtained from wood ashes by exhausting with water, filtering, evaporating, and calcining. This variety is purified by making a

solution, filtering, and evaporating, when the carbonate crystallizes out. A pure form may be prepared from the potassium acid tartrate by burning, making a solution, filtering and crystallizing. The form of carbonate may also be obtained by proper means from the native potassium chloride.

Properties. This salt is very deliquescent, and soluble in water; furnishing a highly alkaline solution.

POTASSIUM ACID CARBONATE, $KHCO_3$.

Preparation. This compound of potassium is prepared by passing a stream of carbonic acid through a solution of the neutral carbonate. Evaporation furnishes a white crystalline body, not quite as soluble as the preceding salt.

Properties. Potassium acid carbonate furnishes a solution nearly neutral to test paper. It is decomposed by heat, giving off carbonic anhydride.

POTASSIUM NEUTRAL SULPHATE, K_2SO_4 .

Preparation. When nitric acid is made from potassium nitrate by the action of sulphuric acid, an acid potassium sulphate remains in the retort; this, when neutralized with potassium carbonate, furnishes the neutral sulphate.

Properties. Its crystals are four-sided prisms, anhydrous, and require a high heat for their fusion. They are not very soluble in water, and are insoluble in absolute alcohol.

POTASSIUM ACID SULPHATE, $KHSO_4$.

Preparation. This salt is prepared by heating the neutral sulphate with strong sulphuric acid. A saturated solution in hot water will deposit rhombo-octahedral crystals.

Properties. This salt is more soluble than the neutral one, and furnishes an acid solution.

POTASSIUM NITRATE, $K_2N_2O_6$, or KNO_3 .

Preparation. This salt may be obtained by several methods; the more common is to decompose sodium nitrate or (chile saltpetre) by a hot concentrated solution of potassium carbonate; concentration by evaporation furnishes, first, sodium carbonate, and lastly potassium nitrate.

Properties. This salt crystallizes in anhydrous, six-sided prisms; it has a saline taste, is very soluble in hot, and less so in cold water. It melts at a temperature below redness, and is completely decomposed at a higher degree.

POTASSIUM CHLORATE, $K_2 Cl_2 O_6$, or $K Cl O_3$.

Preparation. This compound of potassium is prepared by passing a stream of chlorine into a warm solution of potassium carbonate, until the gas is no longer absorbed. After a moderate concentration by heat and then cooling, potassium chlorate crystallizes out. Obtained in this manner the salt is impure, and requires one or two re-crystallizations.



Properties. The crystals of this salt are anhydrous, flat, and tabular; they are decomposed by heat, giving off all of their oxygen. Potassium chlorate is slightly soluble in cold, and more so in hot water.

POTASSIUM CHROMATE, $K_2 Cr O_4$.

Preparation. This salt is made by heating the native chrome iron ore with potassium nitrate. A watery solution, after filtration and evaporation, yields this compound.

Properties. It is a yellow salt, anhydrous, and soluble in water.

POTASSIUM ACID CHROMATE, $K_2 Cr_2 O_7$.

Preparation. This salt is obtained by adding hydric sulphate to a concentrated solution of the chromate; one-half of the potassium is removed, and after concentration potassium acid chromate slowly crystallizes out.

Properties. Potassium acid chromate is red in color, and easily melted; it is soluble in water, the solution having an acid reaction.

POTASSIUM PER MANGANATE, $K_2 Mn_2 O_8$.

Preparation. This salt is prepared by throwing potassium manganate into a quantity of water; hydrated manganese dioxide falls, and potassium permanganate remains in solution. Evaporation will furnish the salt in a crystalline form.

Properties. The crystals have a dark, purple-brown color, are very soluble in water, imparting to that liquid a beautiful purple color.

COMPOUNDS OF SULPHUR WITH POTASSIUM.

There are five sulphides of potassium, having the following composition and symbols:—

<i>Potassium Monosulphide</i>	$K_2 S$.
<i>Potassium Disulphide</i>	$K_2 S_2$.
<i>Potassium Trisulphide</i>	$K_2 S_3$.
<i>Potassium Tetrasulphide</i>	$K_2 S_4$.
<i>Potassium Pentasulphide</i>	$K_2 S_5$.

POTASSIUM MONOSULPHIDE, K, S.

Preparation. This sulphide is said to be formed when hydrogen is passed over heated potassium sulphate.

POTASSIUM DISULPHIDE, K, S₂.

Preparation. When a solution of potassium sulph-hydrate has been exposed to the air long enough to become cloudy, and then evaporated in vacuo, this sulphide is obtained.

POTASSIUM TRISULPHIDE, K, S₃.

Preparation. Potassium trisulphide is obtained when the vapor of carbon disulphide is passed over heated potassium carbonate.

POTASSIUM TETRASULPHIDE, K, S₄.

Preparation. This sulphide is prepared by passing hydrogen sulphide into a melted mixture of potassium carbonate and sulphur.

POTASSIUM PENTASULPHIDE, K, S₅.

Preparation. The pentasulphide is formed when a solution of either of the other sulphides is boiled with an excess of sulphur.

POTASSIUM FERRO-CYANIDE, K₄ Fe Cy₆.

Preparation. This compound is prepared by burning in iron vessels, at a red heat, nitrogenous organic matter, with potassium carbonate and iron filings, care being taken to have an excess of iron. The charred mass is thrown into hot water, which dissolves the ferro-cyanide, and when filtered and evaporated, furnishes the crystals.

Properties. It is a yellow salt, soluble in water, and difficult to powder.

POTASSIUM FERRI-CYANIDE, K₄ Fe Cy₆.

Preparation. This salt, which is sometimes called red prussiate of potash, is made by passing chlorine through a cold solution of potassium ferro-cyanide until the liquid becomes a deep red color. Filtration and evaporation will furnish crystals of this beautiful salt.

Properties. It is a dark red crystalline salt, soluble in water, and burns when introduced into a flame.

POTASSIUM CYANIDE, K Cy.

Preparation. This salt is made by heating a mixture of ferro-cyanide and carbonate of potassium. Pouring off the upper portion of the fluid mass, so that the iron may remain. Prepared in this manner, it will contain a little cyanate.

Properties. It is a white, solid mass, capable of being crystallized, is soluble in water, and does not decompose at low heat.

The salts of potassium are recognized by the following tests:—

A solution of Hydrogen Tartrate—White precipitate.

A solution of Platinic Chloride—Orange-yellow precipitate.

Fluo-silicic Acid—White precipitate.

Perchloric Acid—White precipitate.

SODIUM.

Symbol Na. Combining weight 23.

Specific gravity 0.972.

Discovered by Davy in the year 1808.

Preparation. An intimate mixture of dry sodium carbonate, charcoal and chalk are introduced into a proper vessel and heat applied. The sodium distills over and is condensed.

Properties. This metal is soft, and has a silvery lustre; it melts at a low temperature and distills at a red heat. Sodium is less strong in its affinity for oxygen than potassium.

OXYGEN COMPOUNDS OF SODIUM.

There are two oxides of sodium, also a hydrate.

Sodium Monoxide..... $\text{Na}_2 \text{O}$.

Sodium Dioxide..... $\text{Na}_2 \text{O}_2$.

Sodium Hydrate..... Na H O .

SODIUM MONOXIDE, $\text{Na}_2 \text{O}$.

Preparation. This oxide is made by heating sodium hydrate with metallic sodium.

Properties. It is a gray-colored mass that melts at a red heat.

SODIUM DIOXIDE, $\text{Na}_2 \text{O}_2$.

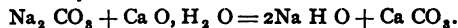
Preparation. This oxide is prepared by heating metallic sodium in a current of dry oxygen.

Properties. It is white, and soluble in water. When a solution is evaporated in a vacuum, crystalline plates are formed.

SODIUM HYDRATE, Na H O .

Preparation. This compound is formed by decomposing sodium carbonate in solution, by calcium hydrate.

Calcium carbonate is formed and falls as a precipitate, sodium hydrate remaining in solution; this solution is treated in the same manner as for making potassium hydrate.



Properties. It is a white, fusible body, having properties similar to potassium hydrate.

SODIUM CHLORIDE, Na Cl.

This well known substance is found native in beds in many parts of the earth, also in solution in the waters of salt springs and wells. It is obtained from these sources by evaporation.

Properties. Common salt, when pure, crystallizes in cubes that are anhydrous. It is soluble in water, insoluble in absolute alcohol.

SODIUM BROMIDE, Na Br.

Preparation. This compound of sodium is obtained by acting on bromine with sodium hydrate, as in making potassium bromide; the reaction being similar.

Properties. These are almost identical with the corresponding potassium compound.

SODIUM IODIDE, Na I.

Preparation. Sodium Iodide is prepared by a process similar to that for obtaining potassium iodide.

Properties. Similar to Potassium Iodide.

SODIUM CARBONATES.

These are three in number; the two of importance have the following names and symbols:—

Sodium Carbonate..... $\text{Na}_2 \text{CO}_3 + 10\text{H}_2 \text{O}$.

Sodium Dicarbonate..... Na H CO_3 .

SODIUM CARBONATE, $\text{Na}_2 \text{CO}_3 + 10\text{H}_2 \text{O}$.

Preparation. This important salt is obtained by a process devised by Leblanc, and consists in converting the chloride of sodium into the sulphate; this is then mixed with calcium carbonate and carbon, and subjected to high heat.

The black ash is thrown into warm water, and from this solution, after filtration and concentration, crystals of the carbonate are obtained.

Properties. It is a crystalline solid body, having ten molecules of water of crystallization. Sodium carbonate is soluble in water, the solution having a strong alkaline reaction.

SODIUM DICARBONATE, Na H CO₃.

Preparation. This salt, generally known as the Bicarbonate of soda, is made by passing a stream of carbonic anhydride into sodium carbonate contained in a large box which has a perforated false bottom. Nine molecules of water are discharged, and the Bicarbonate remains.

Properties. This salt is less soluble than the carbonate; its solution being feebly alkaline.

SODIUM SULPHATES.

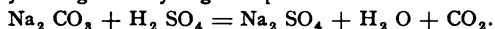
These are two in number and have the following names and symbols:—

Sodium Sulphate..... $\text{Na}_2 \text{SO}_4$.

Sodium Disulphate (Acid)..... Na H SO_4 .

SODIUM SULPHATE, $\text{Na}_2 \text{SO}_4$.

Preparation. This sulphate, commonly known as Glauber's Salt, is obtained by adding dilute hydrogen sulphate to a solution of the carbonate.



Properties. It is a crystalline salt, having 10 molecules of water of crystallization. Sodium sulphate is efflorescent, very soluble in cold, but more so in hot water.

SODIUM DISULPHATE, $\text{Na}_2 \text{SO}_4 \text{H}_2 \text{SO}_4 + 3\text{H}_2 \text{O}$.

Preparation. This salt is obtained by adding to 10 parts of the anhydrous neutral sulphate 7 of oil of vitriol, evaporating the whole to dryness, and gently igniting (Fownes.)

Properties. It does not deliquesce, but when heated undergoes decomposition.

SODIUM HYPOSULPHITE, $\text{Na}_2 \text{S}_2 \text{O}_3$.

Preparation. This salt, which is used so largely in photography, is obtained by gently boiling a solution of the neutral sodium sulphite with sulphur. Slow evaporation at a low heat will furnish the salt in a crystalline form.

Properties. It is a crystalline body, soluble in water, and used in photography for its solvent power of the undecomposed salts of silver.

SODIUM SULPHIDE, $\text{Na}_2 \text{S}$.

Preparation. It is made by a process similar to that for obtaining potassium monosulphide.

Properties. Similar to the corresponding potassium salt.

SODIUM PHOSPHATES.

Each of the three forms of phosphoric acid possess the power to form a salt or salts with sodium; thus, if we view ortho-phosphoric acid as combined with three molecules of hydrogen, each may be replaced by sodium, and form three different orthophosphates having the following composition, as expressed in symbols. $\text{Na}_2 2\text{H}_2 \text{P}_2 \text{O}_8 - 2\text{Na}_2 \text{H}_2 \text{P}_2 \text{O}_8 - 3\text{Na}_2 \text{P}_2 \text{O}_8$. The first of these is acid, the second neutral, and the third alkaline.

Pyrophosphoric acid having two molecules of hydrogen in combination, can therefore form but two salts with sodium by the displacement of hydrogen; as, $\text{Na}_2 \text{H}_2 \text{P}_2 \text{O}_7$ and $2 \text{Na}_2 \text{P}_2 \text{O}_7$.

Metaphosphoric acid has but one molecule of hydrogen in combination, and can therefore form but a single salt with sodium; as, $\text{Na}_2 \text{P}_2 \text{O}_6$.

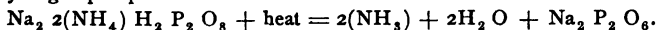
SODIUM ORTHOPHOSPHATES, $2\text{Na}_2 \text{H}_2 \text{P}_2 \text{O}_6$.

Preparation. When a slight excess of sodium carbonate is added to a solution of dihydrogen calcium phosphate, calcium carbon precipitates, and in the solution is the salt, which can be obtained by evaporation.



SODIUM METAPHOSPHATE, $\text{Na}_2 \text{P}_2 \text{O}_6$.

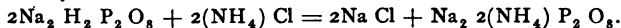
Preparation. This salt is prepared by heating the disodium ammonium hydrogen phosphate.



Properties. It is a classy, crystalline solid body.

DISODIUM AMMONIUM HYDROGEN PHOSPHATE, $\text{Na}_2 2(\text{NH}_4) \text{H}_2 \text{P}_2 \text{O}_6$.

Preparation. When ammonium chloride is added to a concentrated solution of disodium hydrogen phosphate, sodium chloride separates; the liquid when concentrated yields the salt in a crystalline form, which is commonly known as Microcosmic salt.



Properties. This salt contains four molecules of water of crystallization, which are driven off by moderate heat, but if subjected to a higher temperature it undergoes decomposition; ammonia and water passing off, and sodium metaphosphate remains. Microcosmic salt is largely used in blow-pipe experiments.

SODIUM BORATES.

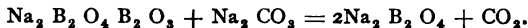
These are two in number, and have the following names and composition:—

Sodium Borate $\text{Na}_2 \text{B}_2 \text{O}_4$.

Sodium Diborate (Borax).. $\text{Na}_2 \text{B}_2 \text{O}_4, \text{B}_2 \text{O}_3 + 10\text{H}_2 \text{O}$.

SODIUM BORATE, $\text{Na}_2 \text{B}_2 \text{O}_4$.

Preparation. This salt is obtained by fusing combining weights of borax and sodium carbonate.



SODIUM DIBORATE (BORAX), $\text{Na}_2 \text{B}_2 \text{O}_4 \cdot \text{B}_2 \text{O}_3 + 10\text{H}_2 \text{O}$.

Preparation. This salt is largely prepared, in the United States, by decomposing the native Calcium diborate with sodium carbonate. Calcium carbonate falls as an insoluble body, the borax remaining in solution. Evaporation will furnish the crystalline diborate.

Properties. Borax is a crystalline salt which effloresces in the air. It is soluble in 20 parts of cold and 6 of boiling water; when heated moderately it parts with its water of crystallization, and if a higher temperature is applied it melts; on cooling it presents a vitreous appearance.

Test. For the sodium salts, is meta-antimoniate of potassium; gives a white precipitate.

LITHIUM.

Symbol Li. Combining weight 7. Specific gravity 0.59.

Discovered by *Arfwedson* in the year 1817.

Preparation. This element can be prepared from the chloride, by first fusing, and then decomposing with galvanic electricity.

Properties. This metal is the lightest of all solids. It is white, like sodium, and melts at 356° F.

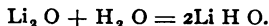
COMPOUNDS OF LITHIUM WITH OXYGEN.**LITHIA, or LITHIUM MONOXIDE, $\text{Li}_2 \text{O}$.**

Preparation. This compound is obtained by heating the metal, or by boiling the carbonate with milk of lime, evaporating to dryness and heating in a silver vessel.

Properties. It is a white, caustic, crystalline body; melts at a white heat, and is insoluble.

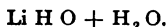
LITHIUM HYDRATE, $\text{Li}_2 \text{H O}$.

Preparation. When the monoxide is thrown into the water, this compound results:—



Properties. It resembles caustic soda or sodium hydrate.

A crystalline hydrate is said to have been made, having the following symbol:—

**LITHIUM CHLORIDE, Li Cl .**

Preparation. This compound is formed by treating lithium carbonate with hydrogen chloride. By evaporation over hydrogen sulphate the crystalline salt is obtained.

Properties. It melts at a low heat, has a specific gravity of 2.074, and is one of the most deliquescent bodies known.

LITHIUM SULPHATE (NORMAL), $\text{Li}_2\text{SO}_4 + \text{H}_2\text{O}$.

Preparation. This salt is formed when hydrogen sulphate is added to lithium carbonate.

Properties. It crystallizes in plates, and is soluble in water and alcohol.

LITHIUM HYDROGEN SULPHATE, LiHSO_4 .

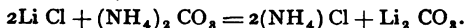
This salt is known, but is of little importance.

LITHIUM NITRATE, $\text{Li}_2\text{N}_2\text{O}_6$, and LITHIUM PHOSPHATE, $3\text{Li}_2\text{P}_2\text{O}_6$.

These salts are also known, but are interesting only to advanced students of chemistry.

LITHIUM CARBONATE, Li_2CO_3 .

Preparation. This compound is formed when a saturated solution of lithium chloride is added to one of ammonium chloride.



Properties. It precipitates as a crystalline powder, which is slightly soluble in water.

Test. The salts of lithium color a flame a blood red.

CÆSIUM.

Symbol Cs. Combining weight 133.

Discovered by *Bunsen* and *Kirchhoff* in the year 1860.

Preparation. This metal has not as yet been obtained in the pure state. It forms a double salt with platinum tetrachloride, like potassium, but is less soluble than the corresponding potassium salt. The hydrate of cæsium is a powerful alkali, and when in the presence of carbonic acid, combines with it, forming, first, a carbonate, and then a bicarbonate, both being soluble in absolute alcohol.

RUBIDIUM.

Symbol Rb. Combining weight 85.4.

Specific gravity 1.52.

Discovered by *Bunsen* and *Kirchhoff* in the year 1861.

Preparation. This metal is obtained in a manner similar to potassium, the same precautions being necessary. Rubidium tartrate is first charred, and then heated to whiteness in an iron tube.

Properties. It is a silvery white metal. At a moderate temperature it is soft, but when heated to 101° F. it melts, and emits a blue vapor.

RUBIDIUM MONOXIDE, Rb_2O .

Preparation. This compound can be prepared by burning the metal in dry oxygen.

RUBIDIUM HYDRATE, RbHO .

Preparation. The hydrate is best prepared by adding baryta-water to a solution of rubidium sulphate, filtering, and evaporating to dryness in a silver vessel.

Properties. It is a grayish-white, deliquescent mass. Roscoe and Schörllemmer.

The following salts of rubidium, with their symbols as given below, are known, and can be prepared by the proper methods:—

<i>Rubidium Chloride</i>	Rb Cl .
<i>Rubidium Chlorate</i>	$\text{Rb}_2 \text{Cl}_2 \text{O}_6$.
<i>Rubidium Sulphate</i>	$\text{Rb}_2 \text{SO}_4$.
<i>Rubidium Nitrate</i>	$\text{Rb}_2 \text{N}_2 \text{O}_6$.
<i>Rubidium Carbonate</i>	$\text{Rb}_2 \text{CO}_3$.

Test. The salts of this metal color a non-luminous flame blood red.

SILVER.

Symbol Ag (Argentum). Combining weight 108.

Specific gravity 10.5.

Preparation. This metal is obtained from its ores by crushing to a fine powder, salting and amalgamating; the mercury is driven off by heat and the silver remains; or by roasting with sodium chloride, and decomposing with scrap iron. From argentiferous galena, by obtaining the lead, and resorting to Pattinson's method. (See any good work on Metallurgy.)

Silver can be obtained nearly pure from silver coin, by forming the nitrates of silver and copper with hydrogen nitrate, decomposing these by sodium chloride, washing out the soluble copper salt, and heating the silver chloride, mixed with argols, to fusion.

Properties. Pure silver is perfectly white in color, and possesses a high degree of lustre; it is very malleable and ductile, and is one of the best conductors of heat and electricity known. It melts at 1873° F., does not oxidize in the air, but when melted absorbs oxygen to the extent of several times its volume.

COMPOUNDS OF SILVER WITH OXYGEN.

These are three in number, and have the following names and symbols. The first is the only one having a well defined existence, and capable of forming salts :—

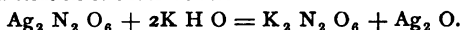
Monoxide or Argentic Oxide..... $\text{Ag}_2 \text{O}$.

Argentous Oxide..... $\text{Ag}_4 \text{O}$.

Silver Dioxide..... $\text{Ag}_2 \text{O}_2$.

SILVER MONOXIDE, or ARGENTIC OXIDE, $\text{Ag}_2 \text{O}$.

Preparation. This oxide is obtained by adding a solution of potassium hydrate to a solution of silver nitrate.



Properties. It is pale brown in color, soluble in ammonia, and is a strong base.

COMPOUNDS OF SILVER WITH CHLORINE.

There are two of these compounds known; one has two atoms of silver to one atom of chlorine, the other having the proportion of one to one. Their names and symbols being as follows :—

Silver Monochloride or Argentic Chloride..... Ag Cl .

Argentous Chloride..... $\text{Ag}_4 \text{Cl}_2$.

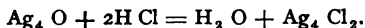
SILVER MONOCHLORIDE, or ARGENTIC CHLORIDE, Ag Cl .

Preparation. This chloride is precipitated when a soluble chloride is added to a solution of Silver Nitrate.

Properties. It is a white precipitate, insoluble in water and hydrogen nitrate. Silver chloride undergoes decomposition by light, especially if organic matter is present. Also by nascent hydrogen, if that element be liberated in its presence. This chloride is freely soluble in ammonia, also in a solution of potassium cyanide and sodium hyposulphite.

ARGENTOUS CHLORIDE, $\text{Ag}_4 \text{Cl}_2$.

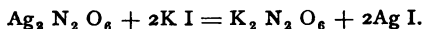
Preparation. This salt is prepared by adding hydrogen chloride to argentous oxide.



Properties. It is decomposed by heat, and converted into silver monochloride and silver.

SILVER IODIDE, Ag I .

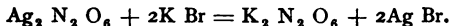
Preparation. This compound falls as a precipitate, when a solution of potassium iodide is added to a solution of silver nitrate.



Properties. It is a yellow precipitate, insoluble in ammonia, but freely so in a solution of potassium cyanide.

SILVER BROMIDE, Ag Br.

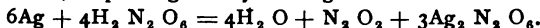
Preparation. This compound falls as a precipitate when a solution of potassium bromide is added to a solution of silver nitrate.



Properties. It is a yellow-white precipitate, insoluble in water, but by an excess of ammonia, or in a solution of potassium cyanide, it quickly dissolves.

SILVER NITRATE, Ag, N, O₆.

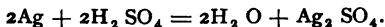
Preparation. This salt is prepared by adding hydrogen nitrate to metallic silver, evaporating and crystallizing.



Properties. This compound of silver crystallizes in colorless, transparent, anhydrous tables; it is soluble in water and alcohol. When melted and cast into sticks it constitutes the lunar caustic of the surgeon. This salt blackens if exposed to sunlight, and is one of the ingredients of indelible ink and of most hair dyes.

SILVER SULPHATE, Ag, SO₄.

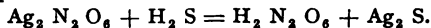
Preparation. This compound is prepared by the direct action of hydrogen sulphate on metallic silver, with the application of heat.



Properties. It is a crystalline body, slightly soluble in water, and if brought into contact with copper, undergoes decomposition, copper sulphate being formed and silver precipitated.

SILVER SULPHIDE, Ag, S.

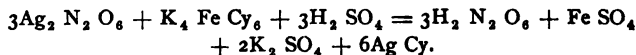
Preparation. This compound falls as a precipitate when a solution of hydrogen sulphide is added to a solution of silver nitrate.



Properties. Silver sulphide is brown in color and is a strong sulphur base.

SILVER CYANIDE, Ag Cy.

Preparation. This compound is prepared by distilling a mixed solution of silver nitrate, potassium, ferro-cyanide and hydrogen sulphate.



Properties. This salt is the one usually employed in the making of hydrocyanic acid.

Tests. A soluble chloride gives a white precipitate, soluble in ammonia, but insoluble in hydrogen nitrate.

A soluble iodide gives a yellow precipitate which is insoluble in ammonia, but freely so in a solution of potassium cyanide.

DYAD METALS.

CALCIUM.

Symbol Ca. Combining weight 40.

Specific gravity 1,5778.

Discovered by *Davy* in the year 1808.

Preparation. This metal can be obtained by heating a mixture of calcium iodide and metallic sodium, placed in layers, in an iron crucible tightly covered. Sodium iodide is formed and calcium remains.

Properties. Calcium is a ductile, yellow metal. It tarnishes in the air, and decomposes water.

COMPOUNDS OF CALCIUM WITH OXYGEN.

These are two in number, and have the following names and symbols:—

Calcium Monoxide..... Ca O.

Calcium Dioxide..... Ca O₂.

CALCIUM MONOXIDE, Ca O.

Preparation. This important compound may be obtained pure by heating to whiteness the precipitated calcium carbonate. That variety used for building purposes is made by heating the native calcium carbonate or limestone.

Properties. It is white, quite hard, and infusible. When moistened with water, it slakes, giving off heat, and falling into a soft, bulky powder, which is a hydrate containing one molecule of water, Ca O H₂ O. It is soluble in cold water. One pint of that liquid at 60° F. will dissolve about 11 grains.

CALCIUM DIOXIDE, Ca O₂.

Preparation. This oxide is prepared by treating lime, or the monoxide, with hydrogen dioxide.

Properties. It resembles barium dioxide.

CALCIUM CHLORIDE, Ca Cl₂.

Preparation. This compound is prepared by adding hydrogen chloride to calcium carbonate.



By the application of a high heat the water is driven off and the crystals fuse.

Properties. It is in irregular lumps, which absorb moisture with avidity. This salt is much used by chemists for drying gases.

CALCIUM IODIDE, Ca I₂.

Preparation. This substance is made by the action of iodine on calcium hydrate. The action being similar to that when potassium iodide is prepared.

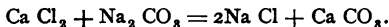
CALCIUM BROMIDE, Ca Br₂.

Preparation. Similar to calcium iodide.

Properties. Calcium iodide and bromide have properties similar to calcium chloride.

CALCIUM CARBONATE, Ca CO₃.

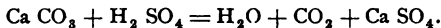
Preparation. This body is found native as chalk, limestone or marble. It may be obtained as a precipitate by adding a soluble carbonate to a solution of a soluble salt of calcium.



Properties. It is white in color, insoluble in water, but if carbonic acid be present it is dissolved, constituting what is known as hard water; if this water is heated carbonic acid is driven off and the carbonate falls.

CALCIUM SULPHATE, Ca SO₄.

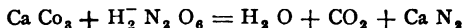
Preparation. This compound is found native and crystalline in *gypsum* and *selenite*. It can be prepared by the action of hydrogen sulphate on a concentrated solution of calcium chloride, or by the addition of hydrogen sulphate to calcium carbonate.



Properties. Native calcium sulphate or Gypsum, when ground to a fine powder and heated to the temperature (260° F.), loses its water of hydration, and becomes what is known as Plaster-of-Paris, an article much used for making casts, molds, etc.

CALCIUM NITRATE, Ca N₂ O₆.

Preparation. This compound is made by the action of hydrogen nitrate on calcium carbonate.



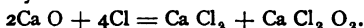
CALCIUM PHOSPHATES.

Preparation. As previously noticed, each of the three forms of Phosphoric acid has the power to form salts. We may, therefore, have Ortho-phosphates, Pyro-phosphates and Meta-phosphates of Calcium, by decomposing the corresponding sodium salts by calcium chloride.

Properties. These phosphates are insoluble in water, but are soluble in dilute acids.

BLEACHING POWDER, $\text{Ca Cl}_2 + \text{Ca Cl}_2 \text{ O}_2$.

Preparation. This compound is made in large quantities by the action of chlorine on calcium hydrate; the chlorine being admitted slowly, that the temperature may remain low.



Properties. The bleaching and disinfectant power of this compound is too well known to require any notice. It contains nearly 28 per cent. of chlorine.

COMPOUNDS OF CALCIUM WITH SULPHUR.

These are three in number, and have the following names and symbols:—

<i>Calcium Monosulphide</i>	Ca S .
<i>Calcium Disulphide</i>	Ca S_2 .
<i>Calcium Pentasulphide</i>	Ca S_5 .

CALCIUM MONOSULPHIDE, Ca S .

Preparation. This sulphide is obtained by decomposing the sulphate with charcoal.

CALCIUM DISULPHIDE, Ca S_2 .

Preparation. This compound is prepared by boiling together calcium hydrate, water, and flowers of sulphur. From the solution, when cold, crystals of the disulphide are deposited.

CALCIUM PENTASULPHIDE, Ca S_5 .

Preparation. When calcium hydrate and water are boiled for a considerable time with an excess of sulphur, this sulphide is formed. It is to be remembered that in these manipulations hyposulphurous acid is formed.

CALCIUM PHOSPHIDE, $\text{Ca}_3 \text{ P}_2$.

Preparation. This compound is prepared by passing the vapor of phosphorus over calcium monoxide heated to whiteness in a porcelain crucible.

Properties. It undergoes decomposition when thrown into water, liberating hydrogen phosphide, which is spontaneously inflammable.

Tests. Ammonium oxalate in solution will form an insoluble white precipitate of Calcium Oxalate when added to a soluble salt of Calcium in solution. Soluble carbonates also form white precipitates, with Calcium salts.

STRONTIUM.

Symbol Sr. Combining weight 87.5.

Specific gravity 2.54.

Discovered by *Hope* in the year 1792.

Preparation. This metal can be obtained by a method devised by *Mathiessen*, which is as follows: "Fill a small crucible, having a porous cell with anhydrous strontium chloride mixed with some ammonium chloride, so that the level of the fused chloride in the cell is much higher than in the crucible. The negative pole placed in the cell consists of a fine iron wire. The positive pole is an iron cylinder placed in the crucible around the cell. The heat is regulated so that a crust forms in the cell, and the metal collects under the crust" (*Fownes*).

Properties. It is a yellow-brown metal, slightly heavy. It oxidizes in the air, and decomposes water.

COMPOUNDS OF STRONTIUM WITH OXYGEN.

These are two in number, and have the following names and symbols:

Strontium Monoxide Sr O.

Strontium Dioxide..... Sr O₂.

STRONTIUM MONOXIDE, Sr O.

Preparation. This oxide is prepared by decomposing the nitrate by heat.

Properties. This body, when thrown into water, is converted into the hydrate, which deposits from a hot concentrated solution in a crystalline form, having the symbol of $\text{Sr H}_2\text{O}_2 + 8\text{H}_2\text{O}$.

STRONTIUM DIOXIDE, Sr O₂.

Preparation. This oxide is obtained by passing a stream of oxygen over the monoxide contained in a porcelain tube heated to redness.

STRONTIUM CHLORIDE, Sr Cl₂.

Preparation. This salt is prepared by adding hydrogen chloride to the native carbonate (strontianite). Hexagonal needles are deposited from a hot concentrated solution having the following symbol:—



Properties. The chloride has a bitter taste, effloresces when exposed to the air, and has a specific gravity of 1.603.

STRONTIUM SULPHATE, Sr SO_4 .

Preparation. This salt is found native (as celestine). It can be prepared by adding a soluble sulphate to a solution of a soluble strontium salt.

Properties. It is insoluble in water, white in color, and has a specific gravity of 3.7.

STRONTIUM CARBONATE, Sr CO_3 .

Preparation. This compound is found native as (strontianite), but can be prepared by decomposing a soluble strontium salt with a soluble carbonate.

Properties. It is white in color, and insoluble in water.

STRONTIUM NITRATE, $\text{Sr N}_2 \text{O}_6$.

Preparation. This salt is prepared by the action of warm dilute hydrogen nitrate on the carbonate. From a concentrated solution it deposits in a crystalline form, having a specific gravity of 2.9.

Properties. It is soluble in water, but its principal use is in the manufacture of red fire.

Test. The strontium salts impart to a colorless flame a beautiful crimson hue.

BARIUM.

Symbol Ba. Combining weight 137.

Specific gravity 1.5.

Discovered by *Davy* in the year 1808.

Preparation. This element is prepared by passing a current of electricity through melted barium chloride.

Properties. It is sometimes obtained as a silver white powder, at others as a porous mass. It oxidizes quickly, and burns when heated in the air.

COMPOUNDS OF BARIUM WITH OXYGEN.

There are two oxygen compounds of the metal, also a hydrate, which have the following names and symbols:—

<i>Barium Monoxide</i>	Ba O.
<i>Barium Dioxide</i>	Ba O ₂ .
<i>Barium Hydrate</i>	Ba H ₂ O ₂ .

BARIUM MONOXIDE, Ba O.

Preparation. This oxide is made by decomposing the crystalline nitrate by heat, until red vapors are no longer given off.

Properties. It is gray, spongy mass, fusible only at a high temperature.

BARIUM DIOXIDE, Ba O₂.

Preparation. This oxide is prepared in a manner similar to that for obtaining strontium dioxide.

Properties. This compound is used in the manufacture of hydrogen dioxide.

BARIUM HYDRATE, Ba H₂ O₂.

Preparation. This body is obtained by adding a hot concentrated solution of barium chloride to sodium hydrate; on cooling crystals are deposited.

Properties. It is a white powder, very soluble in hot water, and has a strong affinity for carbonic acid.

BARIUM CHLORIDE, Ba Cl₂ H₂ O.

Preparation. This salt is obtained by the action of hydrogen chloride on the native carbonate. Filtering and evaporating when the crystals deposit.

Properties. The crystals are four-sided tables, transparent, and without color.

BARIUM NITRATE, B, Na, O₆.

Preparation. This salt is made by the action of hydrogen nitrate on the native carbonate. Filtering, evaporating and crystallizing.

Properties. It is a transparent crystalline body, and soluble in water.

BARIUM SULPHATE, Ba SO₄.

Preparation. This salt is found native as heavy spar. It is obtained by adding dilute hydrogen sulphate to a solution of barium chloride.

Properties. It is white in color, and one of the most insoluble substances known.

BARIUM CARBONATE, Ba CO₃.

Preparation. This salt is found native as *witherite*. It is made by the addition of ammonium carbonate to a solution of barium chloride.

Properties. It is a heavy, white powder, and very slightly soluble in water.

COMPOUNDS OF BARIUM WITH SULPHUR.

There are four sulphides of barium. A monosulphide, Ba S. A Trisulphide, Ba S₃. A Tetrasulphide, Ba S₄, and a Pentasulphide, Ba S₅. These sulphides are of little importance.

Tests. A volatile salt of barium colors a non-luminous flame greenish-yellow. A soluble sulphate forms a white precipitate that is only soluble in boiling hydrogen sulphate.

BERYLLIUM, OR GLUCINUM.

Symbol Be. Combining weight 9.4.

Specific gravity 2.1.

Discovered by *Wohler* in the year 1828.

Preparation. This metal is obtained by decomposing its chloride with melted sodium.

Properties. It is a white, ductile and malleable metal.

BERYLLIUM MONOXIDE, Be O.

Preparation. This oxide is prepared from one of the silicates by heating it in a powdered form with potassium carbonate, treating with hydrogen chloride, evaporating to dryness, again treating with hydrogen chloride, and afterwards with water, etc.

Properties. Similar to alumina.

BERYLLIUM CHLORIDE, Be Cl₂.

Preparation. This chloride is obtained by heating the metal in chlorine gas.

Properties. Soluble in water, volatile and deliquescent.

YTTRIUM.

Symbol Y. Combining weight 61.7. Specific gravity 4.8.

Discovered by *Wohler* in the year 1828.

Preparation. This metal was obtained by Berzelius, by heating the chloride with potassium.

Properties. According to Berzelius, this metal has the color of iron.

ERBIUM.

Symbol Eb. Combining weight 170.5.

Discovered by *Mosander* in the year 1843.

This metal has not been isolated.

LANTHANUM.

Symbol La. Combining weight 139. Specific gravity 6.1.

Discovered by *Mosander* in the year 1841.

Preparation. This metal may be obtained by heating its chloride with potassium.

Properties. It has an iron-gray color, takes a high polish, but soon tarnishes in contact with air.

The following named salts, with their symbols, are known, and can be prepared by proper manipulation. Lanthanum chloride, La Cl_3 . Lanthanum sulphate, $\text{La}_2 3\text{SO}_4 + 9\text{H}_2\text{O}$. Lanthanum nitrate, $\text{La}_2 3\text{N}_2\text{O}_6 + 6\text{H}_2\text{O}$. Lanthanum carbonate, $\text{La}_2 3\text{CO}_3 + 8\text{H}_2\text{O}$, and Lanthanum sulphide, $\text{La}_2 \text{S}_3$.

DIDYMIUM.

Symbol Di. Combining weight 147. Specific gravity 6.4.

Discovered by *Marignac* in the year 1841.

Preparation. This metal is obtained by decomposing the chloride by galvanic electricity.

Properties. It has a pale yellow color, tarnishes if exposed to the air, and burns with a bright flame.

The following salts of this metal are known, but are only interesting to the chemist. Their names and symbols being, Didymium oxide, Di O_3 . Didymium chloride, $\text{Di Cl}_3 + 6\text{H}_2\text{O}$. Didymium bromide, $\text{Di Br}_3 + 6\text{H}_2\text{O}$. Didymium sulphate, $\text{Di}_2 3\text{SO}_4 + 8\text{H}_2\text{O}$. Didymium nitrate, $\text{Di}_2 3\text{N}_2\text{O}_6 + 6\text{H}_2\text{O}$. Didymium carbonate, $\text{Di}_2 3\text{CO}_3$, and Didymium sulphide, $\text{Di}_2 \text{S}_3$.

THORIUM.

Symbol Th. Combining weight 231. Specific gravity 7.9.

Discovered by *Berzelius* in the year 1829.

Preparation. This metal is obtained by decomposing the chloride with potassium.

A monoxide, Th O , a chloride, Th Cl_2 , and a sulphate, Th SO_4 are known, and can be made by the proper methods.

MAGNESIUM.

Symbol Mg. Combining weight 24.

Specific gravity 1.7.

Discovered by *Davy* in the year 1808.

Preparation. This metal is obtained by decomposing the double chloride of potassium and magnesium with metallic sodium.

Properties. It is nearly as white as silver, more brittle, but may be drawn into a wire or rolled into a ribbon. It burns with an intense white light, and tarnishes in moist air.

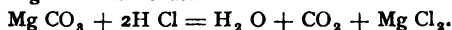
MAGNESIUM MONOXIDE, Mg O.

Preparation. This compound is formed when the carbonate is subjected to a white heat.

Properties. It is a white powder, which absorbs water and carbonic acid.

MAGNESIUM CHLORIDE, Mg Cl₂.

Preparation. This body can be prepared by the action of hydrogen chloride on magnesium carbonate.



Properties. It is a white deliquescent body, soluble in water and alcohol.

A magnesium iodide, Mg I₂, and bromide, Mg Br₂, can be prepared in a manner similar to the corresponding salts of potassium; using magnesia in place of potassium hydrate.

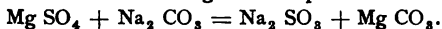
MAGNESIUM SULPHATE, Mg SO₄ + 7H₂ O.

Preparation. There are several sources from which this salt can be obtained. The most common being from salt water, the native silicate, and native double carbonate of magnesium and calcium, called Dolomite. From the double carbonate it can be prepared by adding hydrogen sulphate, filtering, to remove the insoluble calcium salt, and crystallizing by evaporation.

Properties. It is a white crystalline salt, has a bitter taste, and is very soluble in water. When heated it loses 6 molecules of water of crystallization.

MAGNESIUM CARBONATE, Mg CO₃.

Preparation. This salt is sometimes found native, but is prepared by mixing hot saturated solutions of magnesium sulphate and sodium carbonate.



Properties. It is a white insoluble body.

MAGNESIUM PHOSPHATE, Mg₂ H₂ P₂ O₈ + 7H₂ O.

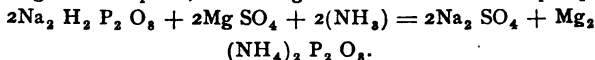
Preparation. This salt is obtained when strong solutions of sodium phosphate and magnesium sulphate are mixed and permitted to stand for some time.



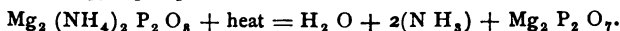
Properties. It is a white crystalline substance, and is slightly soluble in water.

AMMONIUM MAGNESIUM PHOSPHATE, $\text{Mg}_2, 2(\text{NH}_4) \text{P}_2 \text{O}_8$.

Preparation. This salt is formed by making a mixture of Ammonia and Magnesium sulphate, and adding it to a solution of sodium phosphate.



Properties. It is a white, insoluble compound, which, if heated, undergoes decomposition, giving off water and ammonia, and is changed into Magnesium pyro-phosphate.



Test. A white precipitate with ammonia, which is insoluble in an excess, but soluble in a solution of ammonium chloride.

ZINC.

Symbol Zn. Combining weight 65. Specific gravity 7.2.

Discovered by *Paracelsus* in the 16th century.

Preparation. Several ores of this metal are known; the most important are, the Carbonate (Calamine), Silicate and Sulphide (Blende). To obtain the metal, the ore is roasted, then mixed with carbon and heated, when the zinc distills, and is condensed. The operation must be conducted in crucibles made for the purpose, for, if the metal in its vaporous state comes in contact with the air, it takes fire, and is converted into the oxide.

Properties. This metal is blueish-white, tarnishes in the air, and has a crystalline form. It melts at a red heat (773°F.) and volatilizes at a higher temperature. When moderately heated it may be rolled into sheets.

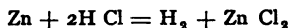
ZINC MONOXIDE, Zn O .

Preparation. This oxide may be prepared by burning the metal or heating the carbonate.

Properties. It is a white powder, without taste, and insoluble in water. It is much used as a pigment when ground with oil.

ZINC CHLORIDE, Zn Cl_2 .

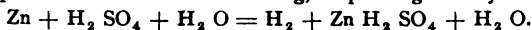
Preparation. This salt is prepared by the action of hydrogen chloride on metallic zinc.



Properties. It is a white salt, fusible, soluble in water and alcohol and deliquescent. Zinc chloride, when in a solution of proper strength, is used for embalming purposes.

ZINC SULPHATE, $\text{Zn SO}_4 \cdot 7\text{H}_2\text{O}$.

Preparation. This compound is prepared by the action of dilute hydrogen sulphate on metallic zinc. Filtering, evaporating and crystallizing.



Properties. This salt, commonly known as white vitriol, is astringent, emetic, and soluble in water.

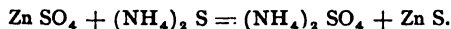
ZINC CARBONATE, Zn CO_3 .

Preparation. This compound is found native. When a soluble carbonate is added to a solution of zinc salt a precipitate is formed, which is a mixture of the carbonate and hydrate.

Properties. It is white in color, and when heated is converted into the oxide.

ZINC SULPHIDE, Zn S .

Preparation. This compound occurs native as (Blende). Zinc sulphide may be prepared by adding an alkaline sulphide to a solution of a soluble salt of zinc.



Properties. It is white in color, and is peculiar in this respect, as the sulphides of most metals are colored, the larger number being black.

ZINC IODIDE, Zn I_2 .

Preparation. This compound is formed by the direct action of iodide on the metal.

Properties. It is dark brown in color, and is one of the most powerful alterative astringents known.

Tests. Potassium hydrate gives a white precipitate which is soluble in an excess of the alkali. Ammonia acts the same. Potassium carbonate gives a white precipitate that is insoluble in an excess. Ammonium carbonate gives a white precipitate soluble in excess.

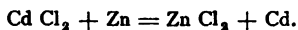
CADMIUM.

Symbol Cd. Combining weight 112.

Specific gravity 8.6.

Discovered by *Stromeyer* in the year 1817.

Preparation. This metal can be obtained by decomposing its chloride with metallic zinc.



Properties. Cadmium in color resembles tin, but is harder; it is malleable, melts at (500°F .), tarnishes in the air, and is volatile.

CADMIUM WITH OXYGEN.

Cadmium combines with oxygen, and forms a Monoxide Ca O ; a hydrate is also known, $\text{Cd } 2\text{H}_2 \text{ O}$.

This metal also forms compounds with sulphur, iodine, hydrogen sulphate, hydrogen nitrate and carbonic acid.

Tests. A fixed alkali gives a white precipitate, insoluble in an excess. Ammonia produces a precipitate which is soluble in that alkali. The carbonate is insoluble in ammonium carbonate.

COPPER.

Symbol Cu (Cuprum). Combining weight 63.5.

Specific gravity 8.9.

Discovered. This metal was known to the Ancients.

Preparation. Copper is sometimes found native, but generally in combination with sulphur, oxygen or carbonic acid. It is obtained from the sulphide by first roasting, then mixing with sand, calcium fluoride, and carbon; high heat is now applied, when reduction takes place, the metal is fused, falls to the bottom of the furnace and is drawn off.

Properties. This metal has its characteristic color, melts at 1200° F. , volatilizes at a higher temperature, is malleable and ductile, and enters into the composition of several important alloys.

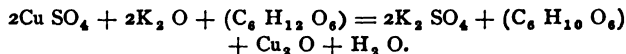
COMPOUNDS OF COPPER WITH OXYGEN.

These are four in number, the two of importance have the following names and symbols:—

<i>Cuprous Oxide</i>	$\text{Cu}_2 \text{ O}$.
<i>Cupric Oxide</i>	Cu O .

CUPROUS OXIDE, $\text{Cu}_2 \text{ O}$.

Preparation. This oxide is sometimes found native. It can be prepared by boiling a solution of copper acetate with glucose, or by the application of heat to a mixed solution of copper sulphate, potassium hydrate and glucose.



Properties. It is dark-red in color, insoluble in water, and when heated unites with oxygen, and becomes converted into the monoxide.

COPPER MONOXIDE, or CUPRIC OXIDE, Cu O .

Preparation. This oxide can be obtained by several processes. Heating copper nitrate, by alternately heating copper and plunging it into

water, or by the addition of potassa to a solution of copper sulphate, and boiling.

Properties. It is black in color, insoluble, and combines with many acids to form salts.

COMPOUNDS OF COPPER WITH CHLORIDE.

<i>Cuprous Chloride</i>	$\text{Cu}_2 \text{Cl}_2$.
<i>Cupric Chloride</i>	Cu Cl_2 .

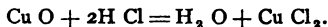
CUPROUS CHLORIDE, $\text{Cu}_2 \text{Cl}_2$.

Preparation. This chloride is prepared by boiling copper in hydrogen chloride with a small quantity of hydrogen nitrate. The product of the continued boiling is thrown into water.

Properties. It is pale green, insoluble in water, but soluble in ammonia.

CUPRIC CHLORIDE, Cu Cl_2 .

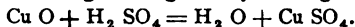
Preparation. This chloride is prepared by the action of hydrogen chloride on cupric oxide.



Properties. It is bluish-green, and contains two molecules of water of crystallization.

CUPRIC SULPHATE, $\text{Cu SO}_4 + 5\text{H}_2 \text{O}$.

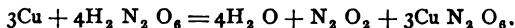
Preparation. This salt is prepared by the action of hydrogen sulphate on cupric oxide; dissolving, filtering and crystallizing.



Properties. Copper sulphate, commonly called blue vitriol, is a crystalline compound, soluble in water, and when heated loses water of crystallization.

CUPRIC NITRATE, $\text{Cu N}_2 \text{O}_6 + 3\text{H}_2 \text{O}$.

Preparation. This is made by the action of hydrogen nitrate on copper.



Properties. It is a deep blue, very soluble in water, and is deliquescent.

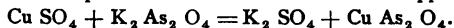
CUPRIC CARBONATE, Cu CO_3 , $\text{Cu O H}_2 \text{O}$.

Preparation. This salt is prepared by adding a solution of sodium carbonate to a solution of Cupric Sulphate. Copper carbonate is found native as Malachite.

Properties. It is pale green, insoluble in water, and used as a pigment.

CUPRIC ARSENITE, $\text{Cu As}_2\text{O}_4$.

Preparation. This compound, called Scheele's green, is prepared by adding a solution of potassium arsenite to a solution of copper sulphate.



Properties. It is emerald green in color, insoluble in water, and is used as a pigment. Like all the other salts of arsenic, it is poisonous.

COMPOUNDS OF COPPER WITH SULPHUR.

Copper forms two sulphides, having the following names and symbols:—

Cuprous Sulphide..... $\text{Cu}_2 \text{S}$.

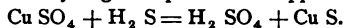
Cupric Sulphide..... Cu S .

CUPROUS SULPHIDE, $\text{Cu}_2 \text{S}$.

Preparation. This sulphide can be prepared by strongly calcining the cupric sulphate. Cuprous sulphide is sometimes found native as *redruthite*.

CUPRIC SULPHIDE, Cu S .

Preparation. This sulphide occurs in nature as *covellite*. It is prepared by the action of hydrogen sulphide on a copper salt.



Properties. The sulphides of copper are black, and insoluble in water.

Tests. The salts of copper may be recognized by the following tests. Potassic hydrate throws down a pale green precipitate, which becomes black on boiling. Ammonia will produce the same precipitate, but dissolves it when in excess. Potassium ferro-cyanide produces a red brown precipitate of copper ferro-cyanide. When any implement of iron having a polished surface is immersed in an acidulated solution of a copper salt it quickly becomes coated with metallic copper.

MERCURY.

Symbol Hg (Hydrargyrum). Combining weight 200.

Specific gravity 13.59.

Discovered. This metal was known as early as 300 years before Christ.

Preparation. This metal is obtained from the native sulphide called *cinnabar*, by roasting in a properly constructed furnace, and condensing the metal; the sulphurous anhydride passing off.

Properties. Mercury is silver white in color; at ordinary tempera-

tures it is liquid; it boils at (662° F.), and freezes at —40 F.). This metal remains unaltered in the air except when heated, when it combines with oxygen. It is largely used in making thermometers, and for obtaining the precious metals.

COMPOUNDS OF MERCURY WITH OXYGEN.

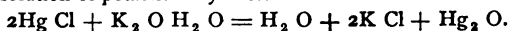
These are two in number, and have the following names and symbols:—

Mercurous Oxide..... $\text{Hg}_2 \text{O}$.

Mercuric Oxide Hg O .

MERCUROUS OXIDE, $\text{Hg}_2 \text{O}$.

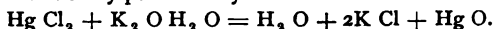
Preparation. This oxide is prepared by boiling mercurous chloride in a strong solution of potassium hydrate.



Properties. It is black in color and unstable.

MERCURIC OXIDE, Hg O .

Preparation. This oxide can be obtained by decomposing Mercuric chloride in solution by potassium hydrate.



Properties. It is yellow when wet, but when washed and dried is red in color; it is commonly known as red precipitate, and is very poisonous.

COMPOUNDS OF MERCURY WITH CHLORINE.

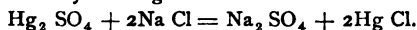
These are two in number, and have the following names and symbols :

Mercurous Chloride..... Hg Cl .

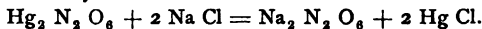
Mercuric Chloride Hg Cl_2 .

MERCUROUS CHLORIDE, Hg Cl .

Preparation. This chloride is prepared by strongly heating a mixture of mercurous sulphate and sodium chloride, and preventing crystallization by steam, and carefully washing.



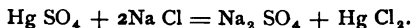
Mercurous chloride can also be obtained by decomposing a solution of mercurous nitrate by sodium chloride.



Properties. It is a white powder, insoluble in water, and much used in medicine by the name of calomel. Its specific gravity is 7.17.

MERCURIC CHLORIDE, Hg Cl_2 .

Preparation. This salt is obtained by subliming a mixture of mercuric sulphate and sodium chloride.



Properties. It is white, crystalline and friable, very poisonous, and has a specific gravity of 6.5. Mercuric chloride is soluble in water.

COMPOUNDS OF MERCURY WITH IODINE.

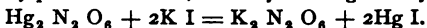
These are two in number, and have the following names and symbols :—

Mercurous Iodide Hg I .

Mercuric Iodide Hg I_2 .

MERCUROUS IODIDE, Hg I .

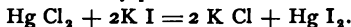
Preparation. This iodide is made by decomposing a solution of mercurous nitrate by potassium iodide, carefully washing and drying.



Properties. It is yellow-green in color, not poisonous, and is insoluble.

MERCURIC IODIDE, Hg I_2 .

Preparations. This iodide is prepared by decomposing a saturated solution of mercuric chloride by potassium iodide.



Properties. When first formed it is yellow, but soon changes to a bright red. It is insoluble in water, but is promptly taken up if potassium iodide is added. Mercuric iodide is a violent poison.

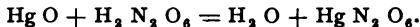
MERCUROUS NITRATE, $\text{Hg}_2 \text{N}_2 \text{O}_6 + 2\text{H}_2 \text{O}$.

Preparation. This salt is prepared by the action of an excess of cold dilute hydrogen nitrate on metallic mercury.

Properties. It is a crystalline salt, without color, soluble in water if slightly acidulated by hydrogen nitrate.

MERCURIC NITRATE, $\text{Hg N}_2 \text{O}_6 + \text{H}_2 \text{O}$.

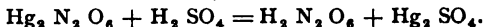
Preparation. This nitrate is formed when an excess of hydrogen nitrate is added to mercuric oxide.



Properties. It is a white, crystalline salt, and when thrown into water undergoes decomposition.

MERCUROUS SULPHATE, $\text{Hg}_2 \text{SO}_4$.

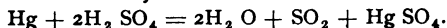
Preparation. This sulphate is obtained by adding hydrogen sulphate to a solution of mercurous nitrate,



Properties. It is a white, crystalline powder, slightly soluble in water.

MERCURIC SULPHATE, Hg SO₄.

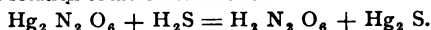
Preparation. This sulphate is made by the direct action of hydrogen sulphate on metallic mercury.



Properties. It is a heavy, white, crystalline salt, and if thrown into water, undergoes decomposition, forming a yellow precipitate, called *turpeth-mineral*, which is a basic sulphate, and has the symbol of $\text{HgSO}_4 \cdot 2\text{HgO}$.

MERCUROUS SULPHIDE, Hg₂ S.

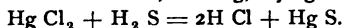
Preparation. This sulphide is obtained when hydrogen sulphide is passed into a solution of mercurous nitrate.



Properties. It is black, and when heated, is converted into mercuric sulphide and mercury.

MERCURIC SULPHIDE, Hg S.

Preparation. This sulphide is prepared by passing hydrogen sulphide into a solution of mercuric chloride, washing, drying and subliming.



Properties. It is dark red, insoluble in water, and known as *vermilion*.

AMIDO-MERCURIC CHLORIDE Hg, (NH₄) Cl.

Preparation. When water of Ammonia is added to a solution of mercuric chloride, this compound precipitates.



Properties. It is white in color, and but little used.

Tests. The liberation of the metal by decomposing its compounds with heat and dry sodium carbonate. Or the precipitation of the metal on gold by transfixing a drop of one of its soluble salts with an iron point.

TRIAD METALS.**GOLD.**

Symbol Au (Aurum). Combining weight 196.7.

Specific gravity 19.5.

This metal was known to the ancients.

Preparation. This precious metal is always found native; but generally associated with silver. It is obtained by the same method as that used to procure silver. Most of the gold obtained is associated with silver and

other metals, from which it has to be separated by the proper methods. Gold melts at 1260° F.

Properties. They are too well known to require any description.

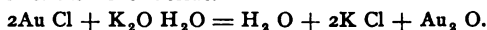
COMPOUNDS OF GOLD WITH OXYGEN.

These are two in number and have the following names and symbols:—

<i>Monoxide, or Aurous Oxide</i>	$\text{Au}_2 \text{O}.$
<i>Trioxide or Auric Oxide</i>	$\text{Au}_2 \text{O}_3.$

AUROS OXIDE, $\text{Au}_2 \text{O}.$

Preparation. This oxide is obtained when potassium hydrate in solution is added to the monochloride.



Properties. It is a green powder, slightly soluble and liable to undergo decomposition.

AURIC CHLORIDE, $\text{Au}_2 \text{O}_3.$

Preparation. This oxide is prepared by adding magnesia to the auric chloride, washing the precipitate and digesting with hydrogen nitrate.

Properties. It is an insoluble, reddish-yellow powder.

COMPOUNDS OF GOLD WITH CHLORINE.

These are two in number, and are as follows:—

<i>Gold Monochloride, or Aurous Chloride</i>	$\text{Au Cl}.$
<i>Gold Trichloride, or Auric Chloride</i>	$\text{Au Cl}_3.$

AUROS CHLORIDE, $\text{Au Cl}.$

Preparation. This chloride is prepared by heating the auric chloride to a temperature of (440° F).

Properties. It is pale yellow in color, insoluble in water, and liable to undergo decomposition.

AURIC CHLORIDE, $\text{Au Cl}_3.$

Preparation. This chloride is obtained by the action of nitro-muriatic acid on the metal gold.

Properties. It is a red, crystalline body, deliquescent, and soluble in water, alcohol and ether.

COMPOUNDS OF GOLD WITH SULPHUR.

These are two in number, and are as follows:—

<i>Aurous Sulphide</i>	$\text{Au}_2 \text{S}.$
<i>Auric Sulphide</i>	$\text{Au}_2 \text{S}_3.$

AUROUS SULPHIDE, Au, S.

Preparation. This sulphide is formed when hydrogen sulphide is passed into a hot solution of auric chloride.

Properties. It is black in color, and forms sulphur salts with potassium and sodium.

AURIC SULPHIDE, Au, S₂.

Preparation. This sulphide precipitates when hydrogen sulphide is passed into a cold dilute solution of auric chloride.

Properties. It is yellow in color, and soluble in ammonium sulphide.

Tests. Salts of gold may be detected by ferrous sulphate, giving a brown precipitate. Stannous chloride gives a purple precipitate (*Purple of Cassius*). Oxalic acid precipitates the metal.

THALLIUM.

Symbol Tl. Combining weight 204. Specific gravity 11.8.

Discovered by *Crookes* in the year 1861.

Preparation. This metal is obtained by decomposing the chloride with hydrogen sulphate and dissolving in water; decomposing the sulphate with hydrogen sulphide, filtering and boiling; ammonia is now added and heat applied, the solution filtered and evaporated, when the sulphate crystallizes out. The sulphate is decomposed by zinc and the Thallium remains.

Properties. It is a soft, heavy metal, of a grayish color, has a crystalline form and melts at 294° F.

COMPOUNDS OF THALLIUM WITH OXYGEN.

These are two in number, and have the following names and symbols:

Thallium Monoxide..... Tl₂ O.

Thallium Trioxide..... Tl₂ O₃.

THALLIUM MONOXIDE, Tl₂ O.

Preparation. This oxide is prepared by heating the hydrate in a vacuum.

Properties. It is a black powder that can be melted at 300° F.

THALLIUM TRIOXIDE, Tl₂ O₃.

Preparation. This oxide is prepared by the action of oxygen on the melted metal.

Properties. It is a dark red powder, insoluble in water and alkalis.

THALLIUM HYDRATE, $TlHO + H_2O$.

Preparation. This compound is made by throwing the metal into water exposed to the air.

Properties. It is a yellow crystalline salt, soluble in water, the solution having an alkaline reaction.

COMPOUNDS OF THALLIUM WITH CHLORINE.

This metal forms four chlorides; the two well defined have the following names and symbols.

<i>Thallium Monochloride</i>	$TlCl$.
<i>Thallium Trichloride</i>	$TlCl_3$.

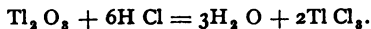
THALLIUM MONOCHLORIDE, $TlCl$.

Preparation. This chloride can be obtained by burning the metal in chlorine, or by decomposing a thallous salt with sodium chloride.

Properties. It is a white crystalline body, soluble in hot water.

THALLIUM TRICHLORIDE, $TlCl_3$.

Preparation. This chloride can be obtained by the action of hydrogen chloride on the trioxide.



Properties. It is soluble in water, is easily melted, and is decomposed by high heat.

COMPOUNDS OF THALLIUM WITH IODINE.

These are two in number, and have the following names and symbols:—

<i>Thallium Moniodide</i>	TlI .
<i>Thallium Triiodide</i>	TlI_3 .

THALLIUM MONIODIDE, TlI .

Preparation. This iodide is made by the direct action of iodine on the metal, or by double decomposition.

Properties. It is a yellow powder which melts below red heat, to a scarlet liquid.

THALLIUM TRIIODIDE, TlI_3 .

Preparation. This iodide is prepared by the action of an ethereal solution of iodine on metallic thallium.

Properties. A dark brown solution which deposits rhombic prisms (Fownes).

The following salts of this metal are known and can be prepared by the proper methods.

Thallium Carbonate, $Tl_2 CO_3$. Thallious Sulphate, $Tl_2 SO_4$. Thallic Sulphate, $Tl_2 3SO_4 + 7H_2O$. Thallium Phosphates, Ortho, Pyro and Meta, and Thallium Sulphide, $Tl_2 S$. The same rule holds good in the phosphorus salts of this metal as in the corresponding one of potassium.

Tests. Thallium is thrown down by ammonium sulphide with iron, nickel, manganese, etc. From these it is separated by precipitation with potassium iodide, or reduction to the metallic condition with zinc.

TETRAD METALS.

TITANIUM.

Symbol Ti. Combining weight 50.

Discovered by Klaproth in the year 1791.

Preparation. This metal has been obtained by heating titanium and potassium fluoride with potassium.

Properties. This element is remarkable for its affinity for nitrogen; when heated in the air, it simultaneously absorbs oxygen and nitrogen (Fownes).

This rare metal forms salts with oxygen, chlorine, fluorine, etc.

TIN.

Symbol Sn (Stannum). Combining weight 118.

Specific gravity 7.3.

This metal was known to the ancients.

Preparation. This metal is found combined with oxygen. It is obtained from the oxide by roasting, powdered, and heating with carbon.

Properties. Tin is white in color, like silver, malleable, not acted on by the atmosphere, and melts at $457^\circ F$.

COMPOUNDS OF TIN WITH OXYGEN.

These, with their symbols, are as follows :—

TIN MONOXIDE or STANNOUS OXIDE, $Sn O$.

Preparation. This oxide can be prepared by heating the oxalate excluded from the air; also from the stannous hydrate by ignition.

Properties. It is a heavy, black powder, which, if touched by a white hot body, takes fire, and is converted into the dioxide.

STANNOUS HYDRATE, $\text{Sn}_2\text{H}_2\text{O}_2$.

Preparation. This hydrate is prepared by decomposing stannous chloride with sodium carbonate.

Properties. It is a white precipitate, and when heated parts with its water.

TIN SESQUIOXIDE, Sn_2O_3 .

Preparation. This oxide is formed when hydrated ferric oxide is added to stannous chloride.

Properties. It is a grayish compound, soluble in hydrogen chloride and in ammonia.

TIN DIOXIDE or STANNIC OXIDE, SnO_2 .

Preparation. This oxide can be prepared by heating stannous oxide in the air.

Properties. It is a yellowish white powder, which by proper treatment can be caused to crystallize.

The dioxide forms two hydrates, both being acids, Hydrogen stannate, H_2SnO_3 , and Hydrogen metastannate, $\text{H}_{10}\text{Sn}_5\text{O}_{15}$, each being able to form salts.

COMPOUNDS OF TIN WITH SULPHUR.

These are three in number, and have the following names and composition:—

Tin Monosulphide..... SnS .

Tin Sesquisulphide..... Sn_2S_3 .

Tin Disulphide..... SnS_2 .

Tests. The stannous salts, with the caustic alkalis, give white hydrates, which are soluble in an excess of the reagent. Ammonia and the alkaline carbonates give white hydrates, which are nearly insoluble. Hydrogen sulphide gives a black precipitate. Stannic salts with fixed alkalis give white hydrates, which are soluble in an excess of the reagent. Alkaline carbonates give white hydrates, which are slightly soluble. Hydrogen sulphide gives a yellow precipitation. Gold trichloride gives a purple precipitate.

ALUMINIUM.

Symbol Al . Combining weight 27.5. Specific gravity 2.5.

Discovered by *Wohler* in the year 1828.

Preparation. This metal is obtained by a method devised by *Deville*, and consists in decomposing the double chloride of sodium and aluminium with metallic sodium, calcium fluoride being used as a flux.

Properties. This metal is very light, has a silvery white color, is malleable, ductile, and capable of receiving a high polish. It enters into the composition of aluminium bronze, an alloy of aluminium with copper.

ALUMINA, Al_2O_3 .

Preparation. This oxide is prepared by the application of high heat to the hydrate, which is formed when ammonia is added to a solution of alum.

Properties. It is white, tasteless, and little acted upon by acids.

Aluminium forms the following hydrates :—

Monohydrate..... $\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$.

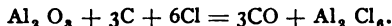
Dihydrate..... $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$.

Trihydrate..... $\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$.

(Fownes.)

ALUMINIUM CHLORIDE, Al_2Cl_6 .

Preparation. This compound is prepared by passing a stream of chlorine over a red hot mixture of alumina and charcoal.



Properties. It is a white crystalline body, fusible, and volatile at 212°F .

ALUMINIUM SULPHATE, $\text{Al}_2(\text{SO}_4)_3 + 18\text{H}_2\text{O}$.

Preparation. This salt is prepared by the action of hydrogen sulphate on those clays which are free from iron.

Properties. It crystallizes in scales, is soluble in water, and when heated loses its water.

ALUMS.

These are double salts, and generally have the same crystalline form (Octahedrons); and are therefore called isomorphous.

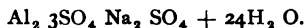
ALUMINIUM AND POTASSIUM DOUBLE SULPHATE.



Preparation. This salt is prepared by mixing hot solutions of Aluminium and Potassium Sulphates, and allowing crystallization to take place.

Properties. It is a transparent crystalline salt, soluble in water, and when heated loses its water of crystallization.

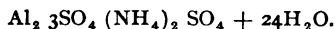
ALUMINIUM AND SODIUM DOUBLE SULPHATE.



Preparation. This variety of alum is made by mixing hot solutions of aluminium and sodium sulphates and allowing to crystallize.

Properties. This alum is difficult to crystallize, but is more soluble than the potassium variety.

ALUMINIUM AND AMMONIUM DOUBLE SULPHATE.



Preparation. This is prepared by mixing hot solution of aluminium and ammonium sulphates, and allowing to crystallize.

Properties. This alum has the same properties as the potassium variety; but if heated to redness yields pure alumina.

There are others alums isomorphous with those described, in which aluminium is replaced by iron, forming with potassium an alum having the composition of $\text{Fe}_2 \text{ } 3\text{SO}_4 \text{ K}_2 \text{ SO}_4 + 24\text{H}_2 \text{ O}$. A chromium and manganese variety can also be prepared.

Tests. Potassic and sodic hydrates give white precipitates which are soluble in an excess of the alkali. Ammonia produces the same precipitate, but it is insoluble in an excess. The precipitate formed by the alkaline carbonates is insoluble in an excess of the reagents.

ZIRCONIUM.

Symbol Zr. Combining weight 89.6.

Specific gravity 4.1.

Discovered by *Berzelius* in the year 1824.

Preparation. This metal is obtained by a method similar to that for preparing Silicon.

Properties. Zirconium combines with oxygen and forms an oxide, Zr O_2 , that acts both as an acid and a base. It also unites with chlorine, forming a chloride, Zr Cl_2 , and with fluorine, a fluoride, Zr Fl_4 .

RHODIUM.

Symbol Rh or Ro. Combining weight 104.4.

Specific gravity 11.

Discovered by *Wollaston* in the year 1803.

Preparation. This metal is obtained from the solution from which Platinum and Palladium were separated, by mixing with hydrogen chloride, and evaporating to dryness. The residue is treated with alcohol of sp. gr. .837, which dissolves everything except the double chloride of rhodium and sodium. This is well washed with alcohol, dried, heated to white-

ness, and boiled with water, whereby the sodium chloride is dissolved out, and Metallic Rhodium remains (Fownes).

Properties. Thus obtained, it is a white, spongy mass, more infusible and less capable of being welded than platinum (Fownes).

Rhodium combines with oxygen, and forms four oxides having the following names and symbols.

A <i>Monoxide</i>	Rh O ₂ .
A <i>Sesquioxide or Rhodic Oxide</i>	Rh ₂ O ₃ .
A <i>Dioxide</i>	Rh O ₂ .
And a <i>Trioxide</i>	Rh O ₃ .

A *Chloride*, Rh₂ Cl₆ and a *Sulphate*, Rh₂ 3SO₄ + 12H₂O, are known, and obtainable by proper methods.

Tests. The salts of this metal are rose colored. The following reagents when added to a solution of a Rhodium salt, respond as follows : Hydrogen sulphide and ammonium sulphide give brown precipitates which are insoluble in an excess. Soluble sulphites give pale yellow precipitates, and potassium hydrate a precipitate also yellow, but is soluble in an excess.

RUTHENIUM.

Symbol Ru. Combining weight 104.4.

Specific gravity 11.4.

Discovered by *Claus* in the year 1845.

Preparation. This metal is prepared from scaly osmiridium, by heating in a porcelain tube, through which a current of air freed from carbonic acid and organic matter is drawn. Osmium and Ruthenium are oxidized, the former being carried forward as a tetroxide and condensed in a solution of potassium hydrate, while the ruthenium remains behind, together with iridium; by fusing this residue with potassium hydrate, treating the mass with water, and leaving the liquid in a corked bottle, for two hours, to clarify, an orange-colored solution of potassium ruthenate is obtained, which, when neutralized with hydrogen nitrate deposits velvet-black ruthenium sesquioxide, and this, when washed, dried, and ignited in hydrogen, yields the metal (Fownes).

Properties. It forms porous lumps, moderately easy to pulverize. It is the most refractory of all metals except osmium (Fownes).

This metal forms compounds with oxygen, chlorine and sulphur, which have the following names and symbols; which can be prepared by the proper methods :—

OXIDES.	CHLORIDES.	SULPHIDES.
Monoxide.....Ru O.	Dichloride.....Ru Cl ₂ .	Monosulphide..Ru S.
Sesquioxide.....Ru ₂ O ₃ .	TrichlorideRu Cl ₃ .	Sesquisulphide,Ru ₂ S ₃ .
Dioxide.....Ru O ₂ .	Tetrachloride..Ru Cl ₄ .	Disulphide.....Ru S ₂ .
Trioxide.....Ru O ₃ .		
Tetroxide.....Ru O ₄ .		

Tests. Potassium ruthenate in solution yields a black precipitate with hydrogen nitrate, which is the oxide; this is soluble in hydrogen chloride, and gives a yellow solution, which, when treated with hydrogen sulphide, to blackness, yields a filtrate of a sky-blue color.

PALLADIUM.

Symbol Pd. Combining weight 106.5.

Specific gravity 11.8.

Discovered by *Wollaston* in the year 1803.

Preparation. When the solution of crude platinum, from which the greater part of that metal has been precipitated by ammonium chloride, is neutralized by sodium carbonate, and mixed with a solution of mercuric cyanide, palladium cyanide separates as a whitish insoluble substance, which, on being washed, dried, and heated to redness, yields metallic palladium in a spongy mass; which can be welded into a mass.

Properties. Palladium resembles platinum in color, is very malleable and ductile. It oxidizes easier than platinum, and is slowly attacked by hydrogen nitrate.

This metal forms compounds with oxygen, chlorine, iodine and sulphur, all of which can be prepared by the proper methods.

PLATINUM.

Symbol Pt. Combining weight 197.4. Specific gravity 21.5.

Discovered by *Wood* in the year 1741.

Preparation. This metal is obtained from crude platinum, which is a native alloy of Platinum, Palladium, Rhodium, Iridium and a little Iron, by acting upon it as far as possible with nitro-muriatic acid, containing an excess of muriatic acid and slightly diluted with water, in order to dissolve as little iridium as possible; to the acid solution ammonium chloride is added which throws down nearly all of the platinum as ammonium-platino-chloride. This, when washed and heated to redness, leaves metallic platinum in a spongy state (Fownes).

Properties. This metal is whiter than iron; it is very malleable and ductile, and melts only at a very high temperature. It is not acted upon by the air, or by the ordinary acids.

COMPOUNDS OF PLATINUM WITH OXYGEN.

These are two in number and have the following names and symbols:—

Platinum Monoxide..... Pt O.

Platinum Dioxide..... Pt O₂.

PLATINUM MONOXIDE, Pt O.

Preparation. This oxide is prepared by decomposing the dichloride with potassium hydrate and heat.



Properties. It is a black powder which is soluble in an excess of the caustic alkali.

PLATINUM DIOXIDE, Pt O₂.

Preparation. This oxide is prepared by double decomposition between solutions of platinum sulphate and barium nitrate, and after filtration the addition of sodium hydrate.

Properties. It is an anhydrous black powder.

COMPOUNDS OF PLATINUM WITH CHLORINE.

These are two in number, and are as follows:—

Platinum Dichloride..... Pt Cl₂.

Platinum Tetrachloride..... Pt Cl₄.

PLATINUM DICHLORIDE, Pt Cl₂.

Preparation. This chloride is prepared by heating the tetrachloride to a moderately high temperature.

Properties. It is a greenish-white powder, insoluble in water, but dissolves in hydrogen chloride.

PLATINUM TETRACHLORIDE, Pt Cl₄.

Preparation. This chloride is obtained by the action of nitro-muriatic acid on metallic platinum.

Properties. The solid salt is brownish-red in color, and is soluble in water and alcohol.

Bromine and Iodine unite with platinum and form compounds similar to the chlorides in composition.

COMPOUNDS OF PLATINUM WITH SULPHUR.

These are two in number and are as follows:—

Platinum Monosulphide..... Pt S.

Platinum Disulphide..... Pt S₂.

PLATINUM MONOSULPHIDE, Pt S.

Preparation. This sulphide can be prepared by the action of hydrogen sulphide on a solution of the dichloride.

Properties. It is a black powder, which is insoluble in water.

PLATINUM DISULPHIDE, Pt S₂.

Preparation. This sulphide is prepared by the action of hydrogen sulphide on a solution of the tetrachloride.

Properties. It is a black powder, insoluble in water, but soluble in the alkaline hydrates, carbonates and sulphides (Fownes).

The compounds of platinum with chlorine, oxygen, hydrogen sulphate, sulphur, etc., combine with other elements and compounds, forming complicated but interesting salts.

Tests. Ammonium chloride gives a yellow precipitate with platinum tetrachloride, which is decomposed by heat into spongy platinum. Ammonium sulphide gives a brown precipitate, which is soluble in an excess of the reagent.

IRIDIUM.

Symbol Ir. Combining weight 198.

Specific gravity 21.15.

Discovered by Tennant in the year 1803.

Preparation. This metal is separated by a complicated method, from the residue, after treating crude platinum with nitro-muriatic acid.

Properties. Iridium is a white, brittle metal, and fusible only at a very high temperature. It is slightly malleable at a red heat, and in density is nearly equal to platinum.

This metal forms compounds with oxygen, chlorine, iodine, sulphur, etc., which can be prepared by proper manipulation.

Tests. Ammonium chloride with iridic solutions gives a precipitate of a dark reddish-brown color, which, when treated with hydrogen sulphide, is reduced to a soluble chloriridite.

OSMIUM.

Symbol Os. Combining weight 199.

Specific gravity 21.4.

Discovered by Tennant in the year 1803.

Preparation. This metal is obtained from osmium tetroxide, by adding an excess of hydrogen chloride, and digesting with mercury in a well closed

bottle, at a temperature of 104° F. The osmium is then reduced by the mercury, and an amalgam is formed, which, when distilled in a stream of hydrogen till all the mercury and calomel are expelled, leaves metallic osmium in the form of a black powder (Berzelius).

Properties. Osmium when in a powder is combustible, and easily oxidized by nitric or nitro-muriatic acids, being converted into the tetroxide. But after it has been exposed to a red heat it loses to an appreciable extent the properties before described (Fownes).

This metal forms compounds with oxygen, chlorine, sulphur and ammonium, etc., that can be obtained by proper methods.

Tests. Osmium compounds, when treated with hydrogen nitrate, give off the unpleasant odor of osmium tetroxide. By ignition in hydrogen they are reduced to the metallic condition (Fownes).

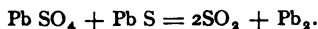
LEAD.

Symbol Pb (Plumbum). Combining weight 207.

Specific gravity 11.4.

Discovered. Lead was known to the Ancients.

Preparation. This metal is obtained from its ore or native sulphide (Galena), by first roasting and then mixing with the unroasted ore; the two are then heated in a reverberatory furnace, when decomposition takes place, and the metal is melted and can be drawn off.



Properties. This well-known metal melts at 617° F. and volatilizes at a white heat.

COMPOUNDS OF LEAD WITH OXYGEN.

These are three in number, and are as follows:—

<i>Lead Monoxide</i>	Pb O.
<i>Triplumbic Tetroxide</i>	Pb ₃ O ₄ .
<i>Lead Dioxide</i>	Pb O ₂ .

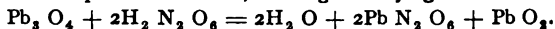
LEAD MONOXIDE, Pb O.

Preparation. This oxide is made by heating the carbonate to dull redness. Litharge is an impure oxide that has been melted.

Properties. It is a pale yellow, very heavy, slightly soluble in water, to which it imparts an alkaline reaction. This oxide melts when heated to approaching redness.

LEAD DIOXIDE, Pb O₂.

Preparation. This oxide is obtained by the addition of hydrogen nitrate to the triplumbic tetroxide, washing and drying.



Properties. It is a dark brown powder; the dioxide is much used for separating sulphurous anhydride from mixed gases.

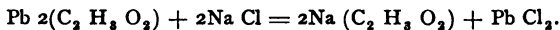
TRIPLUMBIC TETROXIDE, Pb₃ O₄.

Preparation. This oxide is prepared by exposing the monoxide to a faint red heat, in a current of air, for 48 hours.

Properties. It is a bright red, heavy powder, commonly known as red lead, and is much used by the painter as a pigment.

LEAD CHLORIDE, Pb Cl₂.

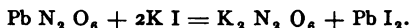
Preparation. This salt can be prepared by the action of a soluble chloride on a solution of lead acetate.



Properties. It is a white crystalline powder, which is soluble in an excess of water.

LEAD IODIDE, Pb I₂.

Preparation. This beautiful salt is prepared by the action of potassium iodide on a solution of lead nitrate or acetate.



Properties. It is a light yellow powder, soluble in hot water, from which it can be crystallized.

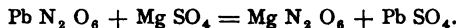
LEAD NITRATE, Pb N₂ O₆.

Preparation. This salt can be prepared by the action of hydrogen nitrate on the monoxide, dissolving in water, filtering, and crystallizing.

Properties. It is an opaque crystalline body, soluble in water, and is decomposed by heat.

LEAD SULPHATE, Pb SO₄.

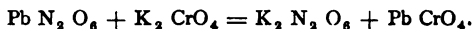
Preparation. This salt can be prepared by the action of a soluble sulphate on a solution of a soluble salt of lead.



Properties. It is an insoluble white powder.

LEAD CHROMATE, Pb Cr O₄.

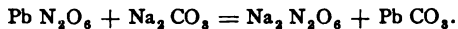
Preparation. This beautiful salt is made by adding potassium chromate to a soluble salt of lead.



Properties. It is a beautiful yellow salt, much used as a pigment, and commonly known as chrome yellow.

LEAD CARBONATE, Pb CO_3 .

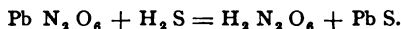
Preparation. This salt can be prepared by the action of sodium carbonate on a solution of lead nitrate.



Or by the process called corrosion. Earthen pots of about half a gallon capacity are used; each of these contains about a quart of vinegar; and on rests which are a short distance above the acids, buckles of lead are placed; a sufficient number having been prepared, they are now placed in alternate layers with spent tan bark; the tops of the pots being protected by boards laid loosely over them. The building being filled now remains undisturbed, and exposed to the air for a period of two months. Chemical action begins; lead acetate is first formed, and this is then converted into the carbonate by that acid which has been formed by the decomposition of the spent tan bark. When the pots are taken out all the acid has disappeared, and the lead carbonate remains; any undecomposed lead is separated, and the carbonate ground and washed, and lastly ground with oil, if white lead for painting is wanted.

LEAD SULPHIDE, Pb S .

Preparation. This compound can be prepared by the action of hydrogen sulphide on a solution of a soluble salt of lead.



Properties. It is a black insoluble body.

COMPOUNDS OF LEAD WITH HYDROGEN ACETATE.

NORMAL LEAD ACETATE, $\text{Pb}_2(\text{C}_2\text{H}_3\text{O}_2)_4 + 3\text{H}_2\text{O}$.

Preparation. This important compound can be prepared by the action of hydrogen acetate on lead monoxide; but it is generally obtained from the wine producing regions of Europe, where the wine has undergone acetic fermentation, thus furnishing large quantities of vinegar. Here sheets of lead are alternately exposed to the air and vinegar, and are in this way corroded and converted into the acetate.

BASIC ACETATES OF LEAD.

These are several in number, and are made by adding lead monoxide, in different proportions, to a concentrated solution of the neutral acetate.

Properties. They are generally white crystalline bodies, which, when added to water, undergo decomposition.

Tests. The white precipitate produced by potassium or sodium hydrate is soluble in an excess of the alkali. Ammonia gives a white precipitate which is insoluble in an excess. Alkaline carbonates give white precipitates, insoluble in an excess. Ammonium sulphide gives black precipitate. Potassium iodide and chromate give yellow precipitates.

MANGANESE.

Symbol Mn. Combining weight 55. Specific gravity 7.2.

Discovered by *Gahn* in the year 1774.

Preparation. Deville obtained this metal by decomposing its carbonate with charcoal, in a crucible made of lime, at a very high heat.

Properties. It is pinkish-gray in color, is hard and brittle, and when powdered decomposes water.

COMPOUNDS OF MANGANESE WITH OXYGEN.

These are six in number, and have the following names and composition:—

<i>Manganous Oxide</i>	Mn O.
<i>Mangano Manganic Oxide</i>	Mn ₃ O ₄ .
<i>Manganic Oxide</i>	Mn ₂ O ₃ .
<i>Manganese Dioxide</i>	Mn O ₂ .
<i>Manganic Anhydride</i>	Mn O ₃ .
<i>Per Manganic Anhydride</i>	Mn ₂ O ₇ .

MANGANOUS OXIDE, Mn O.

Preparation. This oxide is formed when manganese carbonate is heated in a current of hydrogen.

Properties. It is a green powder, which takes fire if touched with a red hot body.

MANGANOSO MANGANIC OXIDE, Mn₃ O₄.

Preparation. This oxide results when the manganous oxide is burned.
 $3\text{Mn O} + \text{O} = \text{Mn}_3 \text{O}_4.$

Properties. It is reddish-brown in color, and is incapable of forming salts.

MANGANIC OXIDE, Mn₂ O₃.

Preparation. This oxide is found native as *braunite*. It can be prepared by heating the dioxide to redness.

Properties. It is dark brown in color, is a feeble base, and is capable of uniting with hydrogen sulphate and crystallizing with potassium or ammonium sulphate, to form an alum.

MANGANESE DIOXIDE, MnO_2 .

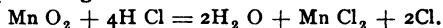
Preparation. This important oxide is found native, as *pyrolusite*. It can be prepared by heating the nitrate to $325^\circ F$.

Properties. It is black, insoluble in water, and will not combine with acids.

Manganic and Permanganic anhydrides are acid-forming oxides, and are capable of uniting with potassa, producing Potassium Manganate and Permanganate.

MANGANESE CHLORIDE, $MnCl_2$.

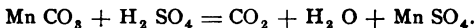
Preparation. This body may be prepared by the action of hydrogen chloride on pure manganese dioxide.



Properties. It is pink in color, crystalline, and when heated undergoes decomposition.

MANGANESE SULPHATE, $MnSO_4$.

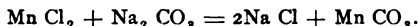
Preparation. This salt can be prepared by adding hydrogen sulphate to manganese carbonate.



Properties. It is a rose-colored crystalline salt, very soluble in water, and much used in dyeing.

MANGANESE CARBONATE, $MnCO_3$.

Preparation. Double decomposition between manganese dichloride and sodium carbonate will form this salt.



Properties. It is a pale rose-colored powder, and when heated in the air gives off carbonic anhydride, and becomes manganoso manganic oxide.

Tests. Alkalies give white precipitates, insoluble in an excess. Alkaline carbonates give white precipitates that are insoluble in an excess; and ammonium sulphide throws down a pinkish white sulphide which is characteristic.

IRON.

Symbol Fe (Ferrum). Combining weight 56.

Specific gravity 7.8.

Discovered. This metal was known to the Ancients.

Preparation. This important metal is sometimes found native, but generally in combination with oxygen.

The principal ores of iron are the magnetic or black oxide, Fe_3O_4 , Red Hematite, Fe_2O_3 , and Spathic iron, or Ferrous Carbonate, FeCO_3 . These ores, when mingled with limestone and carbon, and heat applied, undergo decomposition; carbonic oxide is formed and escapes. The silica combines with the alumina and lime, forming glass or slag, and the iron is melted and falls to the bottom of the furnace, when it can be drawn off. This constitutes cast iron. Wrought iron and steel are forms of iron modified in the process of manufacture.

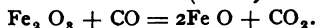
COMPOUNDS OF IRON WITH OXYGEN.

These are three in number, and are as follows:—

<i>Ferrous Oxide</i>	FeO .
<i>Ferric Oxide</i>	Fe_2O_3 .
<i>Ferroso-ferric Oxide</i>	Fe_3O_4 .

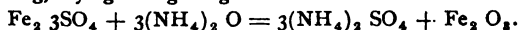
FERROUS OXIDE, FeO .

Preparation. This oxide, when made by the addition of potassium hydrate to a solution of ferrous sulphate, is at first whitish, but soon changes, from the absorption of oxygen, to the higher oxide; it is therefore unknown in the separate state. A method devised by Debray for its manufacture is as follows: Ferric oxide is heated in a current of gas formed of equal volumes of carbon monoxide and carbon dioxide. A black powder remains, which is ferrous oxide (Wurtz).



FERRIC OXIDE, Fe_2O_3 .

Preparation. This oxide occurs native as specular iron ore. Ferric oxide can be prepared by the action of ammonia on a solution of a ferric salt, washing, drying and igniting.



Properties. This oxide is of a red color after ignition, but when in the condition of a hydrate it is light brown, and in this condition is the only antidote for arsenic worthy of mention.

FERROSO-FERRIC OXIDE, Fe_3O_4 .

Preparation. This oxide is found native as Magnetic oxide or loadstone. It can be prepared artificially by adding an alkali to a mixed solution of a ferrous and ferric salt, boiling and filtering.

Properties. It is a black powder, which has magnetic properties.

COMPOUNDS OF IRON WITH CHLORINE.

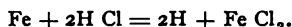
These are two in number, and are as follows :—

Ferrous Chloride..... $\text{Fe Cl}_2 + 4\text{H}_2 \text{ O.}$

Ferric Chloride..... $\text{Fe}_2 \text{ Cl}_6$ or $\text{Fe Cl}_3.$

FERROUS CHLORIDE, $\text{Fe Cl}_2 + 4\text{H}_2 \text{ O.}$

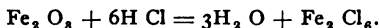
Preparation. This chloride can be prepared by the direct action of hydrogen chloride on metallic iron.



Properties. It is a green crystalline solid, very soluble and deliquescent, and absorbs oxygen from the air.

FERRIC CHLORIDE, $\text{Fe}_2 \text{ Cl}_6$ or $\text{Fe Cl}_3.$

Preparation. This chloride can be made by dissolving ferric oxide in hydrogen chloride.



Properties. It is a red crystalline body, soluble in water and alcohol.

COMPOUNDS OF IRON WITH IODINE.

These are two in number, the Ferrous Iodide, Fe I_2 , and Ferric Iodide, $\text{Fe}_2 \text{ I}_6$. When metallic iron, water and iodide are digested together, iodine combines with the iron; if the metal be in an excess the salt formed will be a Ferrous Iodide, but should the iodine be in excess then Ferric Iodide will be the result.

Properties. Ferrous iodide is pale green in color, is soluble in water, but quickly oxidizes when exposed to the air. Ferric iodide is yellowish red in color and soluble in water.

COMPOUNDS OF IRON WITH HYDROGEN SULPHATE.

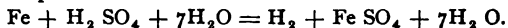
These are two in number and are as follows :—

Ferrous Sulphate..... $\text{Fe SO}_4 + 7\text{H}_2 \text{ O.}$

Ferric Sulphate $\text{Fe}_2 \text{ 3SO}_4.$

FERROUS SULPHATE, $\text{Fe SO}_4 + 7\text{H}_2 \text{ O.}$

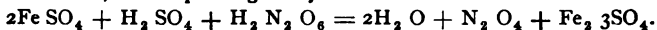
Preparation. This sulphate can be prepared by the action of dilute hydrogen sulphate on metallic iron.



Properties. This beautiful salt, commonly called *green vitriol* or *copperas*, is soluble in water, and crystalline; these crystals slowly effloresce in the air.

FERRIC SULPHATE, Fe_2SO_4 .

Preparation. This sulphate is made by the action of hydrogen nitrate on a solution of ferrous sulphate to which hydrogen sulphate has been added, and evaporating to dryness.



Properties. It is a buff-colored compound, which is slowly dissolved in water. Ferric sulphate is one of the most valuable styptics known.

COMPOUNDS OF IRON WITH HYDROGEN NITRATE.

These are two in number, and are as follows:—

Ferrous Nitrate..... $\text{Fe N}_2\text{O}_6$.

Ferric Nitrate..... $\text{Fe}_2\text{3N}_2\text{O}_6$.

FERROUS NITRATE, $\text{Fe N}_2\text{O}_6$.

Preparation. This salt is prepared by the action of cold dilute hydrogen nitrate on the monosulphide of iron, and evaporating the solution in a vacuum.

Properties. It is a pale green crystalline body, very prone to undergo decomposition.

FERRIC NITRATE, $\text{Fe}_2\text{3N}_2\text{O}_6$.

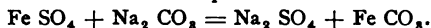
Preparation. This nitrate is prepared by the direct action of hydrogen nitrate on metallic iron.



Properties. It is a deep red liquid, which if evaporated to dryness undergoes decomposition.

FERROUS CARBONATE, Fe CO_3 .

Preparation. This salt is prepared by adding a solution of sodium carbonate to a solution of ferrous sulphate.



Properties. It is a pale green precipitate, which if washed and dried undergoes decomposition and is converted into ferric oxide.

Tests. Ferrous salts in solution give a blue with ferri-cyanide of potassium. Ammonium sulphides gives a black precipitate. Ferric salts in solution give a blue with ferro-cyanide of potassium, and a blood-red with sulpho-cyanide of potassium. Tanno-gallic acid gives a blue black.

NICKEL.

Symbol Ni. Combining weight 58.8.

Specific gravity 8.8.

Discovered by *Cronstedt* in the year 1751.

Preparation. This metal is found native in combination with arsenic as *Kupfernickel*. Nickel can be obtained from its oxalate by high heat and charcoal.

Properties. Nickel is a grayish-white metal, is malleable, ductile, and one of the hardest metals known.

COMPOUNDS OF NICKEL WITH OXYGEN.

These are two in number, and are as follows:—

Nickel Monoxide..... Ni O.

Nickel Sesquioxide..... Ni₂ O₃.

NICKEL MONOXIDE, Ni O.

Preparation. This oxide may be obtained by heating the nitrate to redness.

Properties. It is a gray-colored powder, which unites freely with acids, forming salts.

NICKEL SESQUIOXIDE, Ni₂ O₃.

Preparation. This oxide can be prepared by heating the nitrate.

Properties. It is a black powder, which, if strongly heated, parts with some of its oxygen, and is converted into monoxide.

NICKEL CHLORIDE, Ni Cl₂ + 9H₂ O.

Preparation. This salt can be prepared by adding hydrogen chloride to the monoxide. The solution, on being evaporated, deposits a crystalline chloride, Ni Cl₂ + 9H₂ O. An anhydrous chloride can be obtained by the direct action of chlorine on metallic nickel, if in a finely divided state.

Properties. It is a beautiful emerald-green crystalline salt, and soluble in water.

NICKEL SULPHATE, Ni SO₄ + 7H₂ O.

Preparation. This important salt can be prepared by the action of hydrogen sulphate on the oxide or carbonate.

Properties. It is a green crystalline salt, quite soluble in water, and capable of forming double sulphates with potassium or ammonium. The ammonia-sulphate of nickel in solution is much used for nickel plating.

NICKEL OXALATE, Ni C₂ O₄.

Preparation. This salt can be prepared by adding a strong solution of hydrogen oxalate to nickel sulphate; after the lapse of some time the oxalate precipitates.

Properties. It is a pale, bluish-green, and when subjected to heat, undergoes decomposition, leaving metallic nickel.

NICKEL CARBONATE, Ni CO₃.

Preparation. This compound can be prepared by mixing solutions of sodium carbonate and nickel sulphate.

Properties. This salt falls as a pale green precipitate, and is decomposed by heat.

Tests. The precipitate produced by Potassium hydrate is insoluble in an excess; that formed by Ammonia is soluble in an excess, and furnishes a solution of a deep purple-blue. The carbonates of potassium and sodium give pale green precipitates; Ammonium carbonate, a green precipitate, which is soluble in an excess. Potassium ferro- and ferri-cyanides also give precipitates of a green color.

COBALT.

Symbol Co. Combining weight 59.

Specific gravity 8.6.

Discovered by *Brandt* in the year 1753.

Preparation. This metal can be obtained by calcining the oxalate, and heating in a lime crucible, when a button of the metal is formed.

Properties. It is silvery white, malleable, and magnetic. Cobalt melts at about 1700° F., and is unaffected by exposure to the air, but if heated to a red heat, is converted into an oxide.

COMPOUNDS OF COBALT WITH OXYGEN.

There are several oxides of this metal, the two of importance are as follows:—

Cobalt Monoxide..... Co O.

Cobalt Sesquioxide..... Co₂ O₃.

COBALT MONOXIDE, Co O.

Preparation. This oxide can be prepared by calcining the carbonate.

Properties. It is a pale green powder, forming salts with the acids that are bright red in color.

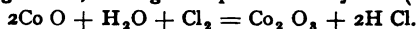
COBALT HYDRATE, Co O H₂ O.

Preparation. This compound is prepared by adding potassium hydrate to a solution of cobalt sulphate.

Properties. It is a rose-colored precipitate.

COBALT SESQUIOXIDE, Co₂ O₃.

Preparation. This oxide can be prepared by passing a current of chlorine through water, holding in suspension the hydrate (Wurtz).



Properties. It is a black powder, combines with acids to form salts.

COMPOUNDS OF COBALT WITH CHLORINE.

These are two in number, and are as follows :—

<i>Cobalt Dichloride</i>	Co Cl ₂ .
<i>Cobalt Trichloride</i>	Co ₂ Cl ₆ .

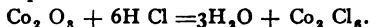
COBALT DICHLORIDE, Co Cl₂.

Preparation. This chloride may be prepared by heating the powdered metal in chlorine, or as a solution by the actions of hydrogen chloride on the monoxide or carbonate, with an excess of the acid and concentration.

Properties. The neutral salt is a light red crystalline body, but when concentrated after the acid has been added becomes blue.

COBALT TRICHLORIDE, Co₂ Cl₆.

Preparation. This chloride is prepared by the action of hydrogen chloride on the sesquioxide.



Properties. It is dark brown in color, and is easily decomposed.

COBALT SULPHATE, Co SO₄ + 7H₂ O.

Preparation. This salt can be obtained by adding dilute hydrogen sulphate to the oxide or carbonate and evaporating.

Properties. It is a red crystalline body, soluble in water.

COBALT CARBONATE, Co CO₃, Co H₂ O₃.

Preparation. This compound is formed when an alkaline carbonate is added to a solution of cobalt sulphate.

Properties. It is pale pink in color, and is an oxy-carbonate.

A nitrate Co N₂ O₆, and an oxalate, Co C₂ O₄, can easily be prepared; the first by the action of hydrogen nitrate on the oxide, or carbonate; and the second by the action of hydrogen oxalate on a solution of the sulphate. There are also several ammonium compounds.

Tests. Potassium hydrate gives a blue precipitate. Ammonium sulphide gives a black precipitate. Ammonia gives a blue precipitate, which is soluble in an excess.

CERIUM.

Symbol Ce. Combining weight 141.2. Specific gravity 6.7.

Discovered. By some authorities the credit of the discovery of this metal is given to *Mosander*; by others to *Berzelius* and *Hisinger*, in the year 1803.

Preparation. This metal can be obtained from the chloride by heating it with metallic sodium, or by decomposing the chloride by means of electricity.

Properties. It has the color and lustre of iron, is malleable and ductile, but tarnishes in the air if moisture be present. Cerium melts at a temperature lower than silver, and burns in a flame, giving out light more brilliant than Magnesium.

COMPOUNDS OF CERIUM WITH OXYGEN.

These are two in number, and are as follows :—

<i>Cerium Sesquioxide</i>	$\text{Ce}_2 \text{O}_3$.
<i>Cerium Dioxide</i>	CeO_2 .

CERIUM SESQUIOXIDE, $\text{Ce}_2 \text{O}_3$.

Preparation. This oxide can be prepared by the heating the oxalate or carbonate in a current of hydrogen gas.

Properties. It is a greenish-blue powder.

CERIUM DIOXIDE, CeO_2 .

Preparation. This oxide can be obtained by heating the chloride with sodium diborate, in a current of air.

Properties. It is a pale yellow crystalline body, which, if heated in a current of hydrogen, is reduced to the metal.

The following salts of this metal can be prepared by the proper methods. Cerium Chloride, CeCl_3 ; Cerium Bromide, $\text{CeBr}_3 + 3\text{H}_2\text{O}$; Cerium Iodide, $\text{CeI}_3 + 9\text{H}_2\text{O}$; Cerium Fluoride, CeF_3 ; Cerium Sulphate, $\text{Ce}_2 3\text{SO}_4$; Cerium Nitrate, $\text{Ce}_2 3\text{N}_2 \text{O}_8 + 6\text{H}_2\text{O}$; and Cerium Oxalate, $\text{Ce}_2 \text{O}_4 + 3\text{H}_2\text{O}$.

CERIUM OXALATE, $\text{Ce}_2 \text{O}_4 + 3\text{H}_2 \text{O}$.

Preparation. This compound is prepared by adding Ammonium Oxalate to a solution of Cerium Sulphate.



Properties. It is a white, granular powder, insoluble in water, decomposed by red heat, to the oxide.

Tests. Ammonia gives a white precipitate, insoluble in excess. Potassium and sodium hydrates give white precipitates, that turn yellow on the addition of chlorine water. Ammonium oxalate gives a white insoluble precipitate, not easily soluble even in hydrogen chloride.

INDIUM.

Symbol In. Combining weight 113.4.

Specific gravity 7.4.

Discovered by *Reich* and *Richter* in the year 1863.

Preparation. This metal can be prepared from its oxide, by heating it to redness in a current of hydrogen, or by fusion with metallic sodium.

Properties. It is a white, non-crystalline metal, malleable and softer than lead, and not acted on by the air or moisture. Indium melts at 348.8° F.

The following compounds of this metal can be prepared by proper methods: Indium Oxide, In_2O_3 ; Indium Chloride, In_2Cl_6 ; Indium Sulphate, $\text{In}_2(\text{SO}_4)_3$; Indium Sulphite, $\text{In}_2(\text{SO}_3)_3 + 4\text{H}_2\text{O}$; Indium Nitrate, $\text{In}_2(\text{NO}_3)_3 + 3\text{H}_2\text{O}$, and Indium Sulphide, In_2S_3 .

Tests. Compounds of Indium, when moistened with hydrogen chloride, color a non-luminous gas flame a dark blue color.

URANIUM.

Symbol U. Combining weight 120. Specific gravity 18.4.

Discovered by *Klaproth* in the year 1798.

Preparation. This metal is found in pitch-blende, which is a native oxide. The metal is obtained from the chloride by decomposing it with metallic sodium.

Properties. It is a black powder, and when fused is white and malleable.

This metal forms compounds with Oxygen, Chlorine, Iodine, Bromine, Fluorine, Hydrogen Sulphate and Hydrogen Nitrate. It also plays the part of an acid when in combination with oxygen in higher quantities, uniting with Sodium, Ammonium, etc., forming salts, the Uranates.

Tests. The uranous salts form green solutions, Potassium hydrate giving them a red-brown precipitate. Sodium carbonate gives a green precipitate which is soluble in an excess. Ammonium Sulphide gives a black precipitate. Uranic salts are yellow, and give with the fixed alkalis yellow precipitates; the alkaline carbonates give yellow precipitates which are soluble in an excess of the reagent. Ammonium sulphide gives a black precipitate.

PENTAD METALS.

VANADIUM.

Symbol V. Combining weight 51.2.

Discovered by *Sefstrom* in the year 1830.

Preparation. An impure metal is obtained by heating the nitrite to whiteness in ammonia gas (*Fownes*).

Properties. It is described as a white, brittle substance, having a strong lustre, and very refractory in the fire (*Fownes*).

This metal forms compounds with the electro-negatives, oxygen, chlorine, sulphur, etc.

Tests. Vanadic and chromic acids are the only acids whose solutions are red; by deoxidation vanadic acid becomes blue, and chromic acid green.

ANTIMONY.

Symbol Sb (Stibium). Combining weight 122.

Specific gravity 6.8.

Discovered by *Basil Valentine* in the year 1460?

Preparation. This metal is obtained from the native sulphide; it is first melted, to free it from earthly impurities, then roasted in the air; the oxy-sulphide thus formed, is powdered, mixed with carbon and sodium hydrate, and calcined; metallic antimony will be found in the bottom of the crucible. The pure metal can be obtained by reducing the oxides with charcoal.

Properties. Antimony is a white metal with a blueish lustre, very brittle, melts at a temperature below redness, and volatilizes at a white heat.

COMPOUNDS OF ANTIMONY WITH OXYGEN.

These are three in number, and are as follows:—

<i>Antimonous Oxide (basic)</i>	$\text{Sb}_2 \text{O}_3$.
<i>Antimonic Oxide (acid)</i>	$\text{Sb}_2 \text{O}_5$.
<i>Diantimonic Tetroxide (neutral)</i>	$\text{Sb}_2 \text{O}_4$.

ANTIMONOUS OXIDE, $\text{Sb}_2 \text{O}_3$.

Preparation. This oxide may be prepared by burning the metal in the air, the operation being conducted in crucibles, one above the other, an opening being in the upper one, that air may enter. Or by decomposing the chlorine with water, and digesting the precipitate with sodium carbonate.

Properties. If prepared by direct oxidation it is crystalline; if by precipitation, it is a pale buff-colored powder. Antimonous oxide is fusible and volatile.

ANTIMONIC OXIDE, Sb_2O_3 .

Preparation. This oxide can be prepared as an insoluble hydrate, by the direct action of hydrogen nitrate on metallic antimony, if the hydrate be heated short of redness, the anhydrous oxide remains.

Properties. As a hydrate, it is a white powder, capable of playing the part of an acid, similar to meta-phosphoric acid; as an anhydride it is a yellow powder, insoluble in water, and decomposable by heat.

DIANTIMONIC TETROXIDE, Sb_2O_4 .

Preparation. This oxide can be prepared by heating antimonous oxide in the air, or by calcining the antimonous oxide.

Properties. It is an infusible, white powder, insoluble in water.

COMPOUNDS OF ANTIMONY WITH CHLORINE.

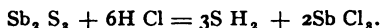
These are two in number, and are as follows:—

Antimony Trichloride..... Sb Cl_3 .

Antimony Pentachloride..... Sb Cl_5 .

ANTIMONY TRICHLORIDE, Sb Cl_3 .

Preparation. This chloride is prepared by the action of hydrogen chloride on the sulphide of antimony, and distilling the product.



Properties. It is a colorless, transparent solid, capable of being melted, but if thrown into water undergoes decomposition.

ANTIMONY PENTACHLORIDE, Sb Cl_5 .

Preparation. This chloride can be prepared by passing a stream of chlorine over gently heated metallic antimony, and distilling the product; the pentachloride will remain, the trichloride passing off.

Properties. It is a yellow, volatile liquid, which cannot be distilled without undergoing decomposition.

COMPOUNDS OF ANTIMONY WITH SULPHUR.

These are two in number, and are as follows:—

Antimony Trisulphide..... Sb_2S_3 .

Antimony Pentasulphide..... Sb_2S_5 .

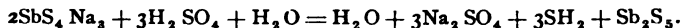
ANTIMONY TRISULPHIDE, Sb_2S_3 .

Preparation. This sulphide, though found native, can be prepared by adding sulphur to melted antimony, or by passing a stream of hydrogen sulphide into a solution of tartar emetic.

Properties. It is a brownish-red powder, insoluble in water, but soluble in potassium sulphide.

ANTIMONY PENTASULPHIDE, Sb, S₅.

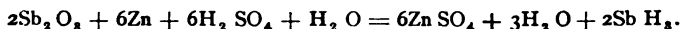
Preparation. This sulphide can be prepared by adding dilute hydrogen sulphate to a solution of sodium sulph-antimoniate.



Properties. It is a golden yellow powder.

HYDROGEN ANTIMONIDE (STIBINE), Sb H₃.

Preparation. This gas can be prepared by the combined action of antimonous oxide, metallic zinc, and dilute hydrogen sulphate.



Properties. This is an inflammable gas, burning with a white flame, forming water and antimonous oxide. If the flame is chilled by a cold porcelain surface, a black spot is formed on it, which is insoluble in sodium hypochlorite.

Tests. The formation of stibine, and its action on porcelain. The reduction of the sulphide with black flux, producing a non-volatile black ring, which, when heated in a current of air gives a non-volatile and non-crystalline white deposit.

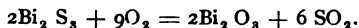
BISMUTH.

Symbol Bi. Combining weight 210.

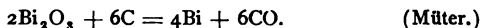
Specific gravity 9.8.

Discovered. By *Agricola* in the year 1529.

Preparation. This metal is obtained from its principal ore, the sulphide (Bi₂ S₃). The ore having been roasted, the reaction occurs :—



This oxide is now heated with charcoal, when metallic bismuth and carbonic oxide result.



Properties. It is grayish, with a pink tinge, melts at 500° F., and volatilizes at a white heat. This metal forms a remarkable alloy which consists of one part of lead, one of tin, and two of bismuth; this alloy melts at a temperature below that of boiling water. Bismuth possesses the remarkable property of expanding on cooling.

COMPOUNDS OF BISMUTH WITH OXYGEN.

These are three in number, and are as follows :—

<i>Bismuthous Oxide</i>	Bi O.
<i>Bismuthic Oxide</i>	Bi ₂ O ₃ .
<i>Bismuthic Anhydride</i>	Bi ₂ O ₅ .

BISMUTHOUS OXIDE, Bi O.

Preparation. This oxide can be prepared from the trichloride by the action of tin monochloride and an excess of potassium hydrate.

Properties. It is a black powder, which, if heated in contact with the air, becomes converted into the bismuthic oxide.

BISMUTHIC OXIDE, Bi₂ O₃.

Preparation. This oxide, the most important of the metal, is prepared by heating the nitrate or the metal in air.

Properties. It is a yellow powder, which becomes brown when heated and fuses easily when a higher temperature is applied.

BISMUTHIC ANHYDRIDE, Bi₂ O₃.

Preparation. This oxide can be prepared by passing chlorine into bismuthic oxide suspended in a strong solution of potassium hydrate, treating with strong hydrogen nitrate and applying heat.

Properties. It is a brown powder, which, if subjected to a high heat, loses oxygen and is converted into a lower oxide.

COMPOUNDS OF BISMUTH WITH CHLORINE.

These are two in number, and are as follows:—

Bismuth Dichloride..... Bi₂ Cl₄.

Bismuth Trichloride..... Bi Cl₃.

BISMUTH DICHLORIDE, Bi₂ Cl₄.

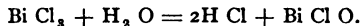
Preparation. This chloride can be prepared by heating the trichloride with metallic bismuth.

Properties. It is a crystalline body, having a brown color, easily fusible, and decomposed by water.

BISMUTH TRICHLORIDE, Bi Cl₃.

Preparation. This chloride can be prepared by heating metallic bismuth in a current of chlorine.

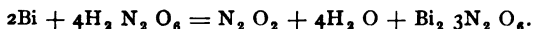
Properties. It is a white body, easily melted, and absorbs moisture from the air and becomes converted into an oxychloride, called pearl white.



Bismuth combines with Iodine, forming a Triiodide, Bi I₃, with Bromine a Tribromide, Bi Br₃, and with Fluorine a Trifluoride, Bi F₃.

BISMUTH NITRATE, Bi₂ 3N₂ O₈ + 3H₂ O.

Preparation. This salt is prepared by the direct action of hydrogen nitrate on metallic bismuth.



Properties. It is a transparent, crystalline, deliquescent solid.

BISMUTH SUBNITRATE, $\text{Bi}_2, 3\text{N}, \text{O}_6, \text{Bi}_2, \text{O}_3 + 3\text{H}_2, \text{O}$.

Preparation. This compound is prepared by throwing the normal nitrate into water.

Properties. It is a white crystalline powder that varies in composition, from the amount of oxide it may contain.

Bismuth combines with sulphur, and forms two sulphides and an oxy-sulphite, as follows:—

<i>Bismuth Disulphide</i>	$\text{Bi}_2 \text{S}_2$.
<i>Bismuth Trisulphide</i>	$\text{Bi}_2 \text{S}_3$.
<i>Bismuth Oxy-sulphide</i>	$\text{Bi}_4 \text{O}_3 \text{S}$.

These compounds are easily prepared by the action of hydrogen sulphide, or by fusing the metallic bismuth with sulphur.

BISMUTH BASIC CARBONATE, $2(\text{Bi O})_2 \text{CO}_2 + \text{H}_2, \text{O}$.

Preparation. This compound is prepared by adding Ammonium Carbonate to a solution of the normal nitrate in dilute hydrogen nitrate.

Properties. It is a white powder, and is to be dried by gentle heat, or it will decompose and become the oxide.

Tests. Hydrogen sulphide gives a black precipitate. Ammonia, potassium and sodium hydrates give white precipitates, insoluble in an excess and becoming changed into the yellow oxide ($\text{Bi}_2 \text{O}_3$) on boiling.

Water causes a white precipitate. Potassium chromate gives a yellow precipitate. Potassium iodide gives a brown precipitate. Alkaline carbonates give white precipitates. Zinc, when added to a solution of bismuth, causes a deposit of metallic bismuth as a dark gray powder (Müter).

NIOBIUM.

Symbol Nb. Combining weight 94.

Specific gravity 4.06 ?

Discovered. The credit of discovery of this metal has been given to *Hatchett*, in the year 1801, also to *Blomstrand*.

Preparation. This metal can be obtained by decomposing the chloride with hydrogen and heat.

Properties. It is steel-gray in color, and is little acted on by the mineral acids, with the exception of hydrogen sulphate.

This metal forms compounds with oxygen, chlorine, bromine, sulphur, etc., which can be prepared by proper methods.

Tests. To a solution of a niobate, hydrogen chloride gives a white pre-

cipitate. Potassium ferro-cyanide, a red precipitate. Potassium ferri-cyanide, a bright yellow precipitate. Infusion of galls, an orange-red precipitate.

TANTALUM.

Symbol Ta. Combining weight 182.

Specific gravity 10.07?

Discovered by *Ekeberg*, in the year 1803.

Preparation. This metal has not yet been separated in a pure form.

This metal combines with oxygen, forming oxides and oxygen acids; with Bromine, Iodine, Fluorine, forming Iodides, Bromides, and Fluorides. Tantalum also forms compounds with Sulphur and Nitrogen.

Tests. Hydrogen chloride gives a white precipitate, soluble in excess. Potassium ferro-cyanide gives a yellow precipitate. Potassium ferri-cyanide gives a white precipitate. Infusion of galls gives a light yellow precipitate (Fownes).

HEXAD METALS.

CHROMIUM.

Symbol Cr. Combining weight 52.4.

Specific gravity 6.81 (Wohler), 7.3 Bunsen.

Discovered by *Vanquelin*, in the year 1797.

Preparation. *Dewille* obtained this metal by subjecting a mixture of sugar and chromic oxide to an intense heat, in a lime crucible.

Properties. It is a light green crystalline powder; it is very hard and difficult to melt. Chromium is not acted on by hydrogen nitrate, but hydrogen sulphate and chloride combine promptly, liberating hydrogen gas.

COMPOUNDS OF CHROMIUM WITH OXYGEN.

There are two basic oxides and one acid-forming oxide of this metal; these oxides unite among themselves, forming compounds.

<i>Chromium Monoxide</i>	Cr O.
<i>Chromium Sesquioxide</i>	Cr O ₃ .
<i>Chromium Trioxide</i>	Cr O ₃ .

CHROMIUM MONOXIDE Cr O.

Preparation. This oxide is not known in any other form but as a hydroxide (Cr O H₂ O). It can be prepared by adding potassium hydrate to a solution of chromium dichloride.

Properties. It is a brownish-yellow precipitate, which, if heated, loses water, and is converted into the chromic oxide.

CHROMIUM SESQUIOXIDE Cr_2O_3 .

Preparation. This oxide can be prepared by firing the hydroxide.

Properties. It is a dirty green, amorphous powder.

CHROMIUM TRIOXIDE Cr O_3 .

Preparation. This oxide, called chromic acid, is prepared by the action of the hydrogen sulphate on a cold saturated solution of potassium dichromate.

Properties. It crystallizes in dark red needles, is very deliquescent and corrosive. Chromium trioxide combines with metallic oxides and forms salts, the chromates.

COMPOUNDS OF CHROMIUM WITH CHLORINE.

These are two in number, and are as follows:—

Chromium Dichloride..... Cr Cl_2 .

Chromium Trichloride..... Cr_2Cl_3 .

CHROMIUM DICHLORIDE Cr Cl_2 .

Preparation. This chloride can be obtained by passing a stream of dry hydrogen over the trichloride heated to redness in a glass tube.

Properties. It is white in color, and is one of the most powerful deoxidizers known.

CHROMIUM TRICHLORIDE Cr_2Cl_3 .

Preparation. This chloride can be prepared by passing a stream of chlorine over a mixture of chromium sesquioxide and charcoal heated to redness in a porcelain tube.

Properties. The trichloride is found in shining scales having a beautiful violet color; it is insoluble in cold, and only sparingly so in hot or boiling water.

There are many other salts of chromium, both simple and compound, that are of interest.

Tests. Chromic salts respond with the following reagents: Barium salts give pale yellow precipitates. Soluble salts of lead give bright yellow precipitates. Mercurous salts give brick red precipitates, and silver salts give crimson precipitates (Fownes).

MOLYBDENUM.

Symbol **Mq**. Combining weight 95.8.

Specific gravity 8.6.

Discovered by *Hjelm* in the year 1782.

Preparation. This metal can be prepared by passing a stream of hydrogen over the chloride, heated to redness.

Properties. It resembles silver in color, but is harder than that metal, and requires for its fusion a high temperature. Molybdenum oxidizes in the air when heated, and decomposes at a red heat. It is not acted on by dilute mineral acids.

This metal forms many interesting compounds with oxygen, chlorine, iodine, bromine, fluorine, sulphur, etc., all of which can be prepared by proper methods. A salt of this metal, the Ammonium Molybdate (NH_4)₂ MoO₄ is used as a test for a soluble phosphate, and is very delicate, giving a yellow precipitate, phospho-molybdate of ammonium.

Tests. Soluble salts of this metal respond with reagents as follows: Hydrogen sulphide gives a blackish precipitate, which is soluble in ammonium sulphide. Alkalies and Alkaline carbonates give a brownish-black precipitate, soluble in potassium dicarbonate; potassium ferrocyanide gives a dark brown precipitate, and sodium phosphate, a white precipitate (Fownes).

TUNGSTEN.

Symbol **W** (Wolfram). Combining weight 183.5.

Specific gravity 19.1.

Discovered by *Juan, José and Fausto d'Elhujar*, Spanish chemists, in the year 1783.

Preparation. This metal can be obtained as a powder by igniting the pure trioxide in a porcelain tube and passing a current of dry, pure hydrogen over it (Roscoe).

Properties. It has a gray metallic lustre, does not oxidize in dry or moist air, but at a red heat unites with oxygen, being converted into the trioxide.

This metal unites with oxygen, forming both oxides and oxygen acids; these acids combine and form salts with bases, especially with potassium and sodium; with the latter metal several tungstates are known. Tungsten also combines with Chlorine, Bromine, Iodine and Sulphur. *Marignac* gives formulæ for three compounds of tungsten with silicic acid.

Tests. Soluble salts of this metal, when super-saturated with sulphuric, hydrochloric, phosphoric, oxalic or acetic acids, yield, on the introduction of a piece of zinc, a beautiful blue color due to tungsten oxide (Fownes).

The following analytical tables, taken from Vacher's Primer of Chemistry, are recommended, for their simplicity and brevity; and may be of service to the student :—

ANALYTICAL TABLES.

TABLES FOR THE DETECTION OF METALS IN SOLUTIONS OF MIXED SUBSTANCES,

GENERAL TABLE.

Add HCl and filter					
<i>Precipitate.</i> AgCl HgCl PbCl ₂		<i>Filtrate.</i> Pass H ₂ S and filter.			
Wash and examine by Table I.		<i>Precipitate.</i> PbS HgS Bi ₂ S ₃ CuS CdS		<i>Filtrate.</i> Add AmCl, AmHO and Am ₂ S and filter.	
		Soluble in Am ₂ S AB		<i>Precipitate.</i> Add Am ₂ CO ₃ and filter.	
		Wash and examine by Table II.		<i>Filtrate.</i> Add Am ₂ CO ₃ and filter.	
				<i>Precipitate.</i> NiS CoS FeS MnS ZnS CH ₃ CO ₃ AlH ₃ O ₃	
		Wash and examine by Table III.		<i>Precipitate.</i> Add Am ₂ CO ₃ and filter.	
		Wash and examine by Table IV.		<i>Filtrate.</i> Mg K Na Am	
				Examine by Table V.	

TABLE I.

Treat on the filter with hot water.		
<i>Filtrate.</i>	<i>Residue.</i>	<i>Residue.</i>
Add H_2SO_4	Treat on the filter with $AmHO$.	
White p. = Pb .	<i>Filtrate.</i>	is black = Hg' .
	Add excess of HNO_3 .	
	White p. = Ag .	

TABLE II.

Transfer to dish, warm with Am_2S and filter.		
<i>Residue.</i>	<i>Filtrate.</i>	<i>Filtrate.</i>
Heat with HCl c. + $KClO_3$, filter, to filtrate add $SnCl_2$ and warm. A black p. = Hg'' .	Wash, dissolve in watch-glass, in least quantity of HCl , and add H_2O . Milkiness = Bi .	<i>Filtrate.</i> (If blue, Cu is present.) Add excess HCl , then excess H_2S , filter off p., boil it with H_2SO_4 dil., filter off insoluble CuS , and add H_2S . A yellow p. = Cd .
	<i>Precipitate.</i>	
	<i>Filtrate.</i>	
	Add H_2SO_4 dil., and filter.	
	<i>Filtrate.</i>	
	Add excess $AmHO$ and filter.	
	<i>Precipitate.</i>	
	<i>Filtrate.</i>	
	Add HCl in excess, filter, wash the p. and dry it. Divide in 2 parts.	
	1. Boil with strong HCl , dilute, filter into platinum crucible lid, add Zn (black stain = Sb). Remove Zn , boil p. with strong HCl , filter, and to f. add $HgCl_2$ p. = Sn .	
	2. Fuse with $KCy + Na_2CO_3$ in ignition tube. Mirror = As .	

TABLE III.

Transfer to dish, treat with cold dilute HCl, stir well and filter.

Residue. Dissolve in HCl + KClO_3 , nearly neutralize with NaHO , add KNO_3 and H_2A till acid, allow to stand some hours and filter.

Filtrate. Boil to expel H_2S , add a little strong HNO_3 ; boil, nearly neutralize with NaHO . When cold add excess BaCO_3 , and filter.

Precipitate. Wash and divide into 3 parts.

1. Dissolve in HCl, and add AmCys . A red color = Fe .

2. Boil with Na_2OCl_2 , and

filter. A yellow f. = Cr .

3. Boil with NaHO , filter,

to f. add excess HCl, then excess AmHO , and warm. p. = Al .

Filtrate. Add dil. H_2SO_4 , drop by drop till in excess, filter off BaSO_4 , evaporate to small bulk, add excess NaHO and filter.

Precipitate.

Test in Na_2CO_3

Filtrate. Add H_2S . A white p. = Zn .

Precipitate.
Test in borax
bead for Co .

Filtrate.

Add NaHO ,
filter and test
p. in borax
bead for Ni .

TABLE III, *bis*.

It is possible that with Gr. III, the following substances may be precipitated, Ba, Sr, Ca, Mg as phosphates, borates, fluorides, silicates, and SiO_2 . The method below is given by FRESNIUS to meet this case.

Treat with cold dil. HCl and filter.

Residue. Wash, test a portion in microcosmic bead in outer bp. flame.

A skeleton = SiO_2 .
A pale reddish-brown color when cold = Ni.

A blue color = Co.

Incinerate rest of residue and test for F by heating in a pt. cr. with H_2SO_4 .

If F is present, treat the contents of the pt. cr. with a little H_2O and add an equal volume of alcohol, CaSO_4 will be left.

If the color of the bead was ambiguous, precipitate traces of Fe by AmHO , evaporate to dryness, ignite gently, dissolve in aqua regia, evaporate nearly to dryness, add KNO_3 and HA till acid, allow to stand some hours and filter off yellow p. (Co). To f. add NaHO , filter and test p. in borax bead for Ni.

Filtrate. Boil to expel H_2S , filter if necessary, and divide in two parts.
2. Add H_2SO_4 , d. and filter. Wash and test the *precipitate* on pt. wire for Ba and Sr. Mix the *filtrates* with three volumes of alcohol, collect the p., dissolve in H_2O , and test for Ca with Am_2O .

2. Add strong HNO_3 and boil. Test a small portion for Fe with AmCyS . To the rest add FeCl_3 (to separate PO_4 and SiO_4) till a drop gives a yellowish p. on a watch glass with AmHO , evaporate to a small bulk, add H_2O , nearly neutralize with Na_2CO_3 , add excess BaCO_3 , allow to stand and filter.

Precipitate. Wash, boil for some time with NaHO and filter.

Dry the *residue* and test for Cr by fusing with KClO_3 and Na_2CO_3 .

Acidify the *filtrate* with HCl, add AmHO just in excess and boil. The p. may be Al_2O_3 and SiO_2 . Collect it on a filter and test a portion in microcosmic bead. If Si is present, ignite rest of p. on pt. cr. lid, add KHSO_4 , fuse, treat with HCl and test the solution with AmHO for Al.

Filtrate. Add HCl, boil to expel CO_2 , add AmHO and Am_2S . Filter.

Precipitate. Wash with H_2O and a little Am_2S , treat with cold dil. HCl and filter.

Examine the *residue* for Ni and Co (if not already found) by washing, incinerating, dissolving in aqua regia, etc.

Boil the *filtrate* to expel H_2S entirely, add HNO_3 , boil, filter off S if necessary, evaporate to small bulk, add excess NaHO , boil and filter.

Precipitate. Examine for Mn in Na_2CO_3 bead.

Filtrate. Test with H_2S for Zn.

Filtrate. Add H_2SO_4 , d., boil, filter off BaSO_4 , add excess AmHO , then Am_2O , filter off CaO and test for Mg with Na_2HPO_4 .

TABLE IV.

Disolve on filter in warm dil. HCl, and evaporate carefully to dryness. Dissolve a portion of the residue in a little water, to the solution, add large volume CaSO_4 , and allow to stand.

No precipitate is formed = **Ca**.

A precipitate is formed after some time = **Sr**. Dissolve rest of residue in water, boil with Am_2SO_4 and AmHO for some time, filter off SrSO_4 , and to f. add Am_2O . A p. = **Ca**.

A precipitate is formed immediately = **Ba**. Digest rest of residue with alcohol, powdering it in the dish with a pestle, filter off the BaCl_2 , to f., add H_2SO_4 , and filter. Wash p. with dilute alcohol, boil it with Am_2SO_4 and AmHO for some time and filter.

<i>Residue.</i>	Test for Sr on platinum wire in Bunsen flame.	<i>Filtrate.</i>	Dilute and add Am_2O . A p. = Ca .
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TABLE V.

To a portion of the solution add Na_2HPO_4 , stir well and allow to stand. A crystalline p. = **Mg**.

If Mg is absent. Evaporate rest of solution to dryness, ignite till white fumes cease, dissolve the residue in the least quantity of water, filter if necessary into a watch-glass, and test for K and Na as below.

If Mg is present. Evaporate rest of solution to dryness, ignite till white fumes cease, warm residue with a little water, add BaH_2O_2 till alkaline, boil, filter, to f. add Am_2CO_3 , warm gently, filter, evaporate f., ignite, dissolve residue in least quantity of water, add a drop of HCl, pour solution into watch-glass, and test for K and Na as below.

Dip a clean platinum wire into the solution, and hold it in Bunsen flame, a yellow color = **Na**. Then add PbCl_4 to the solution and stir; a yellow p. = **K**. If no p., evaporate to dryness on water bath, add a drop or two of water, and observe whether yellow powder remains undissolved.

Warm the original substance with NaHO in a test tube. A smell of NH_3 = **Am**.

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